DEGRADED AND WASTELANDS OF INDIA

STATUS AND SPATIAL DISTRIBUTION

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FOREWORD

The task of providing food security to our country's burgeoning population is becoming increasingly difficult. This challenge must and needs to be met in the face of the changing consumption patterns, impacts of the climate change and degradation of the finite land and water resources. Management of land resources, in general, and potentially culturable lands in particular, encompasses, crop production methods that will keep pace with country's food needs, sustaining environment, blunting impacts of climate change, preserving and enhancing natural resources, and supporting livelihood of farmers and rural population in the country. Thus, there is a pressing need for enlarging area under arable lands, by the way of reclaiming degraded lands for sustainable intensification of agriculture, in which crop yields can be increased without compromising and yielding to adverse environmental impacts and without reducing area under forests.

Per capita availability of inelastic land resource is rapidly declining in relation to annual population growth of 1.4% in the country. Increasing GDP growth is expanding urbanization and industrialization and, therefore, more and more of agricultural lands are being utilized for non-agricultural purposes. The complex interplay of natural and anthropogenic processes compounds problems of land-use planning further. Maintaining and enhancing productive potential of our land resources is vital for progressive introduction of sustainable technologies, and thereby resilience in crop production.

The science of crop management and agricultural practices suited to lands exposed to different abiotic stresses at present demands a specific orientation for meeting challenges of the food insecurity. In this scheme of agricultural development, effective utilization, rejuvenation and management of degraded and wastelands by public and private investments becomes imperative. As a first step, a reliable set of estimates of the degraded and wastelands is essential. In addition to the type and the extent of degradation the lands have undergone or are undergoing, appropriate management strategies need to be designed and implemented in a defined time-frame to bring these lands to 'productive health'.

In this context, the NAAS initiated efforts for integration and streamlining of land-based and remotely sensed revised databases in the Geographical Information System Environment so that a harmonized database is made available for use by the planning departments. Dr S. M. Virmani (Natural Resource Management Scientist), Dr P. S. Roy, Deputy Director, National Remote Sensing Centre and Dr J. S. Samra, the then Deputy Director-General, Natural Resource Management (ICAR), now Executive Director, the National Rainfed Area Authority and all the Fellows of the Academy, were requested to undertake harmonization of disparate databases on degraded and wastelands into most practical classes that respond to amendments. These classes, in the due course, could be considered for optimizing investment portfolios in greening degraded lands and in blunting impacts of climate change; and also objectively allocating resources in such initiatives of the Mahatma Gandhi National Rural Employment Guarantee Act such as, afforestation, watershed development, recharging of groundwater, increasing biodiversity and for other schemes aiming at reclamation and conservation of land for enhancing human welfare and natural resource productivity.

The NAAS and the ICAR understood from the inception that there will always be trade-offs and local complexities. To be useful to the planners, administrators, decision-makers and fund managers of the land-based agricultural development programmes for varied purposes, district-level data in agro-ecological regional framework would be required. The National Bureau of Soil Survey and Land-Use Planning, a natural resource assessment institution of the ICAR, was assigned this work, and the first approximation data produced by the institution is given in this book. As we adopt new high-tech science tools and as natural resource relevant additional data become available from the remote-sensing satellites, further refinements will be made in the innovative database analytic systems. We are confident that this would be of immense benefit to researchers, planners and farmers in their endeavour towards enhancing agricultural production.

President (NAAS) Director-General (ICAR)

PREFACE

Sustainable agricultural development and food security will be one of the key challenges for India in this century. Around 70% of the India's population is living in rural area with agriculture as their livelihood support system. The vast majority of Indian farmers are small and marginal. Their farm size is decreasing further due to population growth. And the quality of the land is deteriorating due to heightened nutrient mining, soil erosion, increasing water scarcity, adverse impacts of climate change and accumulation of toxic elements in soil and water. Land degradation, like climate change, is an anthropogenic-induced process and poses biggest threat to sustainable livelihood security of the farming communities across the country. All of these factors combined with increased rate of land degradation are contributing towards decline in agricultural productivity leading to food insecurity. Since land resources are finite, requisite measures are required to reclaim degraded and wastelands, so that areas going out of cultivation due to social and economic reasons are replenished by reclaiming these lands and by arresting further loss of production potential. State level and Country level information has already been published by the National Remote Sensing Agency (now NRSC). The first order need of the day, therefore, is to prepare a national degraded and wastelands map downscaled to districts. In addition, the nature and causes of the land degradation, and the degree and extent of damaged lands need to be determined, so that developmental agencies in participation with stakeholders proactively adopt measures to reclaim degraded lands for distancing food insecurity, a real challenge.

This book builds-on and integrates work done by different institutes of the ICAR and the Department of Space in the area of degraded and wastelands. It has 11 chapters and chapterwise contents are outlined herewith. Chapter 1 ***Introduction***, narrates problems associated with loss of productivity and soil quality. Centrality of land resources in relation to climate change, environmental concerns and loss of biodiversity are also discussed both in the national and global perspectives. Chapter 2 on ***Historical Background*** reviews efforts made over the last half a century by the Ministry of Agriculture, Indian Council of

Agricultural Research, National Wasteland Development Board, and the National Remote Sensing Agency (now National Remote Sensing Centre) to classify and map degraded soils and wastelands. This chapter also traces steps taken over the past decade to refine common categories of wastelands in the maps produced by the NRSA and the soil degradation map of the NBSS&LUP. Chapter 3, ***Geographical Scenario of India*** defines location, diversity of climates, physiography of the country and their impacts on the development of varied soils, landforms and land use. Chapter 4, ***Generation of Input Datasets*** describes data sources for mapping land degradation by incorporating datasets on water erosion, wind erosion, soil acidity and soil salinity generated through collaborative efforts of the ICAR Institutes. Chapter 5, ***Methodology*** describes harmonization process developed in the GIS core and followed for obtaining realistic estimates of the degraded and wastelands. Chapter 6, ***Spatial Distribution of Degraded and Wastelands*** contains resultant map of the harmonization exercise showing degraded and wastelands of India by various degradation processes. Chapter 7 describes detailed distribution of area of the various categories of degraded and wastelands in 20 AERs. The AER-based data can be used to simulate abiotic stressed land resources availability, use and production potentials.

Extent and distribution of degraded and wastelands in different states of India is given in Chapter 8. This chapter contains maps and statistics, statewise and districtwise of the degraded and wastelands. The datasets on the kinds of land degradations, their area and spread are tabulated and mapped. And the land resource inventory is georeferenced and can be used for launching programmes to rehabilitate and vegetate degraded and wastelands. Chapter 9 discusses severity ranking of different states for different types of degraded lands. Chapter 10 describes scientific and technical relevance of this study. The importance of the data and spatial distribution of the degraded lands across the country in agroecological regions and in states/districts for planning departments is included for implementation of conservation agriculture. Chapter 11 enlists operational use of maps of datasets on degraded and wastelands by various ministries of the Government of India, the NGOs, and by the public institutions at large.

To bring this important document in this format lots of efforts have been made by different agencies, and many personnel were involved at various stages. We would like to express our sincere thanks to all. Dr R.K. Batta, who technically scrutinized the document, deserves a foremost place of appreciation with particular reference to his ability to work relentlessly. Dr H.M. Pateria and Dr M. Osman have been a great help to check scientific and technical names

besides providing some additional beneficial information for improving this document. Dr T.P. Trivedi (Project Director), DIPA and his team deserves special thanks for bringing out this publication in time.

We also duly acknowledge help rendered by personnel of the NBSS&LUP, specially to Shri Sunil Meshram for processing all maps using GIS, and Smt Rohimi Watekar for word-processing the job. Support given by the staff-members of the Director's Technical Cell of the institute is also duly recognised. The administrative support provided by Shri Rakesh Kumar, Sr Administrative Officer and Shri Sachin Agnihotri, Administrative Officer is duly acknowledged. The staff of the NAAS secretariat, led by Shri H.C.Pathak, Executive Secretary, also provided all necessary support wherever required. Ms Minu Tiwari, Mr Umesh Rai and P. Krishna were of great help at various stages of finalization of this book. We would be failing in our duty if we do not recognize two other persons, Dr S.M. Virmani, who facilitated all inter-organizational meetings, mentored analyses of the databases and encouraged the NBBS&LUP to complete this assignment, and in the same vein to Ms Shashi A. Verma, Editor (English) for copy-editing the book, for offering helpful suggestions, enthusing authors for finalization of document, formatting chapters and for overseeing compilation of the draft for final printing. Without their help, we believe, the book would not have been placed in its framework and architecture. Both of them were a great source of inspiration and continued support throughout the process of completing this book.

Finally, we would like to place on record our sincere thanks to Dr S. Ayyappan, Director-General, ICAR, and Secretary, DARE, Dr Mangala Rai, President, National Academy of Agricultural Sciences and Dr A.K. Singh, Deputy Director-General (Natural Resource Management), ICAR, for committing all necessary support for completing this task in the defined time-frame.

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CONTENTS

HISTORICAL BACKGROUND

Land degradation or deterioration of land quality for agricultural production and environmental protection has been a matter of concern for land users. Land degradation assessment undertaken by the various Central and State agencies resulted in the generation of databases on the degraded and wastelands. But these agencies had used varying definitions of land degradation, data sources, classification systems, methodologies and scales that resulted in diverse estimates of degraded and wasteland areas (Table 1). And for proper implementation of reclamation/conservation and ameliorative measures, harmonized/uniform data are required.

The earliest assessment of the area affected by the land degradation was made by the National Commission on Agriculture at 148 M ha, followed by 175 M ha by the Ministry of Agriculture (Soil and Water Conservation Division). The NBSS&LUP estimates projected an area of 187 M ha as degraded lands in 1994 following GLASOD methodology (Oldeman, 1988), and revised it to 147 M ha in 2004. The National Wasteland Development Board estimated an area of 123 M ha under wastelands.

In the preparation of the soil degradation and wasteland maps, two distinct approaches were followed by the NBSS&LUP and the NRSA. The NBSS&LUP followed process-based degradation mapping methodology in agricultural and non-agricultural areas, derived from 1 : 250,000 soil map, showing soil family association prepared from the satellite data supported with soil profile studies (Table 2).

The NRSA followed remote-sensing technology, identifying land-use and physical condition of the surface features for mapping non-agricultural areas (presently non-arable) on 1 : 50,000 scale using satellite image of late *rabi* season with adequate field checks (Table 3).

The differences in Tables 2 and 3 are mainly owing to the adoption of different approaches for the generation of maps. This led to incompatible databases and statistics, which posed difficulties for decision-makers. After intensive deliberations on the datasets of wastelands and soil degradation, a harmonized classification system comprising wasteland classes and soil

Table 1. Land degradation assessment by different organizations

Agency	Estimated extent (M ha)	Criteria for delineation
National Commission on Agriculture (NCA, 1976)	148.09	Based on the secondary data
Ministry of Agriculture (1978) (Soil and Water Conservation Division)	175.00	Based on the NCA's estimates. No systematic survey was undertaken
Society for Promotion of Wastelands Development (SPWD) (Bhumbla and Khare, 1984)	129.58	Based on the secondary estimates
NRSA (1985)	53.28	Mapping on 1 : 1 million scale based on the remote-sensing techniques
Ministry of Agriculture (MOA, 1985)	173.64	Land degradation statistics for states
Ministry of Agriculture (MOA, 1994)	107.43	Elimination of duplication of area. Area reclaimed counted
NBSS&LUP (1994)	187.70	Mapping on 1 : 4 million scale based on the Global Assessment of Soil Degradation (GLASOD) guidelines
NBSS&LUP (2004) (revised)	146.82	1 : 1 million scale soil map
Department of Environment (Vohra, 1980)	95.00	
National Wasteland Development Board (1985)	123.00	

Source: Gautam, N.C. and Narayan, L.R.A. 1988

Table 2. NBSS&LUP soil degradation classes, derived from 1 : 250,000 soil map (1985–1995)

Classes	Codes	Area (in M ha)
Water Erosion	W	
Loss of top-soil	Wt	83.31
Terrain deformation	Wd	10.37
Wind Erosion	E	
Loss of top-soil	Wt	4.35
Loss of top-soil/terrain deformation	Et/Ed	3.24
Terrain deformation/overblowing	Ed/Eo	1.89
Chemical Deterioration	C	
Salinization	Cs	5.89
Loss of nutrients (En) – (Acid soils)	En	16.03
Physical Deterioration	P	
Waterlogging	Pw	14.29
Others		
Ice caps/Rock outcrops/Arid mountain	I/R/M	8.38
Total		147.75

Source: NBSS&LUP. 2004

Table 3. NRSA wasteland classes (1986–2000)

Wasteland class	Area (in M ha)	Percentage
Gullied/ravinous land	2.06	0.65
Land with/without scrub	19.40	6.13
Waterlogged/marshy land	1.66	0.52
Land affected by salinity	2.04	0.65
Shifting cultivation area	3.51	1.11
Degraded notified forest land	14.07	4.44
Degraded pastures/grazing land	2.60	0.82
Degraded land under plantation	0.58	0.18
Sandy area	5.00	1.58
Mining/industrial wasteland	0.12	0.04
Barren rocky/stony/sheet rock	6.46	2.04
Steep sloping area	0.77	0.24
Snow covered/glacial area	5.58	1.76
Total	63.85	20.16

Note: Total wastelands are estimated at 63.85 M ha, correlating with strong, extreme and part of moderate categories of land degradation
Source: NRSA and MoRD. 2000

Table 4. Common categories of wasteland map (NRSA) and soil degradation map (NBSS&LUP)

Wasteland map (1986–2000)	Area (in M ha)	Soil degradation map (1986–1995)	Area (in M ha)
Gullied and ravinous land	2.06	Terrain deformation (includes agricultural land)	10.37
Land affected by salinity/alkalinity	2.04	Salinization (including slight salinity category)	5.89
Waterlogging	1.66	Waterlogging (including sub-surface waterlogging)	14.29
Snow-covered glacial area	5.58	Ice caps	4.10
Total	11.34	Total	34.65

Source: NRSA and NBSS&LUP

degradation has been prepared. The statistics reported under the degraded and wastelands have been compared considering commonality (Table 4)/ dissimilarity of classes, and a harmonized/combined statistics has been worked out.

Based on the area statistics presented in Table 4 and discussions, a preliminary assessment has been made. As per this, the total area under degraded and wastelands in the country stands at 114.01 M ha. The extent of area under water erosion is 23.62 M ha, and under wind erosion is 8.89 M ha.

Chemical degradation comprises salinization/alkalization and acidification (< 5.5 *p*H). Area under salt-affected soils is 6.73 M ha and under acid soils is 16.03 M ha. Under waterlogging, two categories, surface ponding and sub-surface waterlogging, have been identified. Vegetal degradation with water erosion includes land with/without scrub, degraded forest–scrub dominated, agricultural land inside notified forest, degraded pasture/grazing land, degraded land under plantations and abandoned and current shifting cultivation areas of wasteland map, prepared by the NRSA. Other categories include mining and industrial waste, barren rocky/stony waste and snow-covered/ice caps, occupying 12.17 M ha (Table 5).

Table 5. Preliminary area statistics of degraded and wastelands of India[1]

Degradation type	Area[2](in M ha)	Land use
Water Erosion		
Loss of top-soil	13.25	Mainly agricultural areas
Gully formation	8.31	Mainly wastelands and partly agriculture
Ravines	2.06	Mainly wastelands
Wind Erosion		
Loss of top soil	3.76	Mainly agricultural areas
Over blowing	1.89	Partly agriculture and partly wastelands
Terrain deformation	3.24	Mainly wastelands
Chemical Degradation		
Salt-affected soils	6.73	Partly agricultural and partly wastelands
Land degradation due to acidity	16.03	Mainly agriculture areas and partly wastelands
Physical Degradation		
Waterlogging		
Surface ponding	1.66	Mainly wastelands
Subsurface waterlogging	4.75	Mainly agricultural areas
Vegetal Degradation with Water Erosion	40.16	Mainly wastelands
Others		
Mining and industrial waste	0.13	Wastelands
Barren rocky/stony waste	6.46	Wastelands
Snow covered area/ice caps	5.58	Wastelands
Total area	114.01	

Notes: **1.** Statistics encompasses degraded lands in agricultural areas and wastelands; **2.** The results given in this table are preliminary, and are based on the incomplete information. Further studies on the harmonization of the area statistics were taken up inter-institutionally, which are given in Chapter 4

It was felt that normalization of the area statistics was possible only through scientific and logical reasoning, and was decided, therefore, to bring different agencies to one platform for expressing their views to come to an acceptable and agreeable solution. In this endeavour, the National Academy of Agricultural Sciences took a pioneering step to bring all the agencies together through a

series of meetings and deliberations. The first meeting was held on 28 March 2006 in the NRSA (presently NRSC, Hyderabad).

The subgroup-V of the Planning Commission on the natural resources emphasized importance of this exercise, and a consortium of the NRSA and the ICAR Institutes was formed to resolve this issue of disparity in datasets generated by the various organizations using spatial data integration in the GIS environment for arriving at the mutually agreed estimates on the land degradation for planning future strategies.

3 GEOGRAPHICAL SCENARIO OF INDIA

India can be called as a land of paradoxes—a girdle of high-snow capped mountains, glaciers and high-altitude forests in the north; seas washing both sides of lengthy coastline in the peninsular south; and a variety of geological formations, diversified climates and varied topographies and reliefs. The lofty mountains are highest in the world and river deltas are raised a few metres above the mean sea level. And temperatures vary from arctic cold to equatorial hot. Precipitation varies from less than 100 mm in the arid regions to 11,000 mm/yr in the per-humid regions. This geographical setting provides the country with a landscape of diversity of high plateaux, stumpy relic hills, shallow open valleys, rolling uplands, fertile plains, swampy lowlands and dreary barren deserts and a variety of soils developed on these landforms.

LOCATION

India has a total geographical area of 328.2 M ha with a cultivated area of 141 M ha. The country is situated between 8°04′ to 37°06′ N latitudes and 68°07′ to 97°25′ E longitudes. It is bounded by the great Indian Ocean in the south, Arabian sea in the west, Bay of Bengal in the east and the Himalayas in the north. It stretches from 3,214 km north to south and 2,933 km east to west.

CLIMATE

India has diversified climates with three distinct main seasons (rainy, winter and summer). Rainy season spans from June to September, winter season from October to February, and summer from March to May. July–September is the principal rainy season almost for the entire country, when 70–90% of the total rainfall is received in most of the areas located above 16° N latitude, except Ladakh plateau, Kashmir Himalayas and southern tips of Deccan peninsula. Some rains are received as winter rains during October–February. Annual rainfall varies from 100 mm in Thar Desert of Rajasthan to over 11,000 mm in Cherrapunji—Mawsynram of Meghalaya. Mean annual rainfall pattern indicates that east coast receives over 1,500 mm of rains. West coast, excluding small pockets near Thiruvananthapuram; north-eastern states, excluding rain-shadow area of Khasi-Jaintia hills; and many places of sub-Himalayan West Bengal,

receive more than 2,500 mm. Northern plains comprising Punjab, Haryana and western Uttar Pradesh receive 500–750 mm rainfall. Western Haryana and Rajasthan and south-west Punjab receive rainfall of 150–500 mm. In some pockets in the immediate eastern foothills of the Sahyadris (central and south Sahyadris), on an average, 500–600 mm of rainfall is received.

Mean annual temperature in the country varies from 8° to 28°C. Variation in the mean summer and mean winter temperature in the northern region is <10°C and in the south, it is <5°C. During winter in extreme north, mean temperature varies from less than 10°–20°C and in Peninsular plateau, it varies from 22° to 25°C. During summer, temperature rises to 25°–30°C in the central peninsula, >32°C in the north-west areas, and < 25°C in the north-east region. In monsoon season (June, July, August), temperature varies between 25° and 30°C throughout the country, except Rajasthan, where it is higher than 32°C. After withdrawal of the monsoons, with the advent of winter (October), temperature ranges from 25° to 27°C in most of the places. Maximum temperature observed during May–June is in the west Rajasthan, where it is as high as 55°C. In April, along the west coast, highest temperature recorded is 37°C. In eastern Madhya Pradesh, Chhotanagpur plateau, eastern part of Vidarbha and in adjoining Andhra Pradesh, temperature may rise to 47.5°C during May. In other parts of the country, summer temperature generally varies from 37° to 45°C.

During December–January, lowest temperature of –2.5°C is recorded in Drass valley in Jammu and Kashmir. In western and north-western parts of India, average minimum temperature is generally less than 7.5°C during January. North Deccan plateau and some parts of central India experience temperature between 10° and 17.5°C. Southwards temperature reaches up to 22.5°C in south Deccan plateau and adjoining areas. In eastern parts (Bengal basin), mean minimum temperature ranges between 10° and 12.5°C. Similarly, in the north-eastern parts, winter temperature remains between 10° and 12.5°C, excepting parts of Nagaland and upper Asom valley, where minimum temperature is less than 10°C.

PHYSIOGRAPHY

India is divided into four major physiographic divisions: (i) Northern mountains (ii) Hill regions, Indian Peninsula and Eastern plateau (iii) The great Indo-Gangetic plains and Coastal plains and (iv) The Islands

Northern Mountains

Himalayas are not a single continuous chain or range of mountains, but a series of parallel or converging ranges intersected by valleys slopping steeply towards the northern plains of India and gently towards the north-west. The northern slopes are covered with a thick dense growth of forest vegetation

while the southern slopes are precipitous and bare. The valleys extending along the northern border, along the Pakistan border in the west and the Burmese border in the east have sparse forest vegetation. The Himalayan region is further sub-divided into: Western Himalayas, Eastern Himalayas, Western Siwaliks, North-Eastern Hill ranges.

Western Himalayas. This region located between 29°05′ to 37°05′N latitudes and 72°40′ to 81°00′E longitudes represents mountain ranges with snow-covered peaks and large longitudinal valleys. The region has complex geological history from Archaean to Recent. It consists of Kashmir valley, the Himachal and Uttarakhand regions. The Ganges, the Yamuna and the Kali constitute the major river system of the region.

Eastern Himalayas. This region lying between 26°30′ to 29°30′N latitudes and 88°02 to 97°05′E longitudes is characterized by great Himalayan peaks, the central basin and Darjeeling ridges. The region is dissected by numerous rivers and their tributaries. The great Brahmaputra basin forms the natural drainage of the region. The river system of the region is formed by the Tista, Toras, Lohit, Wong Chu, Mechu, Subansiri, Sankosh and the Siang.

Western Siwaliks. The region sloping south with scarps and piedmont plains bordering Gangetic plains is formed by outgoing streams known as *Choas* and the Siwaliks that dip into elongated structural valleys to the north known as *Duns*.

North-eastern Hill Ranges and Valleys. This region lying between 21°57′ to 29°28′N latitudes and 89°45′ to 97°25′E longitudes is a component of the Asom-Myanmar geological province and constitutes hills of Arunachal Pradesh, Manipur, Meghalaya, Mizoram, Nagaland and Tripura and Cachar plains. The elevation of this region increases towards north-east and ranges between 900 and 2,100 m above the mean sea level.

The Brahmaputra valley is a well demarcated unit within the Eastern Himalayas, Patkai and Naga hills, Garo-Khasi-Jaintia and Mikir hills. The valley extends from eastern most tip of Asom to west of Dhubri on the border of the Bangladesh. The valley in its northern margin is characterized by steep slopes but its southern margin has a gradual fall from southern ranges. It is 90-km wide in the upper Asom and about 50-km wide in its middle part and grows to 65 km in the lower Asom. Northern bank of Brahmaputra is marked by formation of oxbow lakes, marshy tracts and *tarai* to semi *tarai* conditions with dense forest cover. The southern part is narrow, and is mostly used for cultivation of tea and paddy in the upper Asom, and paddy and jute in the lower.

Hill Regions, Indian Peninsula and Eastern Plateau

The Peninsula. It is one of the most stable landforms. It is built up of large

and small undulating plateaux with summits seldom rising to more than 1,200 m above the mean sea level. Its gentle gradients are due to prolonged weathering and denudation. The Vindhya, Aravalli, Cudappah, Gondwana and Deccan trap are geological formations constituting peninsular India.

Western Ghats. These consist of north Sahyadri, central Sahyadri, Nilgiris and south Sahyadri and run parallel to west coast from north to south for about 480 km with an average width of 30 to 45 km. These are marked by Harishchandragarh and Mahabaleshwar peaks and highlands of Kudremukh, Annamalai and Palni flat summits, and terraced surface and uneven slopes.

Eastern Ghats. These are highly dissected hills running in a semi-circular fashion bordering the East coast, and consist of Eastern Ghats and uplands in Tamil Nadu. The plateau of Machkund and Koraput, the scarp of Madugular Kondas and the gneissic piedmont plateau of Malakangiri are other important features of the Eastern Ghats.

Deccan Plateau. It consists of Satpura range of Maharashtra plateau in the north (North Deccan Plateau) and Karnataka and Telanganan plateau in the south (South Deccan Plateau). North Deccan Plateau is built up of nearly horizontal sheets of lava and is associated with elongated ridges, escarpments, mesas and buttes and valley. South Deccan Plateau has rolling surface with gentle slopes.

Eastern Plateau. It is represented by Baghelkhand plateau, Chhotanagpur plateau, Garjat hills and Mahanadi basin at elevation ranging from 200 to 900 m above the mean sea level. The landscape exhibits a peneplain surface with rugged topography and includes rounded hills and plateaux. The plateaux are highly dissected, giving rise to escarpments.

Central Uplands. These are elevated lands to the south of Ganga rising from 300–1,200 m above the mean sea level. These comprise Malwa plateau, Aravalli ranges, Madhya Bharat Pathar and Rajasthan uplands, the Bundelkhand uplands and the Narmada valley.

The Great Indo-Gangetic Plains and Coastal Plains

The Indo-Gangetic Plains. These plains are aggradational plains formed by the rivers, the Ganges and the Brahmaputra. They include Indus plain, Rajasthan plain, Punjab plain, Ganga plain and Brahmaputra valley and extend from extremely arid and semi-arid environments of Rajasthan in the west to humid and per-humid Brahmaputra valley in the east. The elevation varies from 150 to 300 m above the mean sea level with low land gradients. The southern margin of the plains is in contact with the edge of the southern uplands and is often encroached by projections of peninsular masses, sometimes up to the banks of the Ganges.

Coastal Plains. These constitute two main coastal regions, one along the Arabian Sea in the west and the other along the Bay of Bengal in the east. The general elevation of these plains is less than 150 m above the mean sea level. Western coastal plain forms a narrow belt of 10 to 25 km, extending from Surat to Kanyakumari and comprises Kerala plain, Karnataka coast, Konkan coast, Kachchh peninsula, Gujarat plain and Kathiawar peninsula. East coastal plain is widely curving and comprises Utkal plain, Andhra plain and Tamil Nadu plain. Broad deltas are built up in this area by the Godavari and the Krishna rivers.

The Islands

There are two groups of Islands namely the Arabian Sea Islands and the Bay of Bengal islands

Arabian Sea Islands. These islands comprising Lakshadweep, Amindivi, Minicoy, and others numbering 25 are the remnants of the old landmass and subsequent coral formations. The basin separating islands from mainland is about 2,000-m deep.

Bay of Bengal Islands. Total of 222 islands that form the Bay group of islands extend over a length of 590 km and a width of 58 km in a crescent shape. These represent tertiary fold axis rising as high as 750 m from the mean sea level. The northern group of Andaman islands is physically characterized by the central range and narrow valleys whereas middle and southern groups have wider flats flanked by the Ghats. The west coast of the islands is surrounded by corals about 32-km away from the shore. Nicobar islands are hilly and form the summit of the submarine mountain range, characteristically irregular in form.

Macro-level variations in physiography enumerated above bring about variable geomorphological environments of soil formation related to structure, process and age of landforms not only in the major regions but within the region. Well-defined soil regions of the country are referred to as soils of Indo-Gangetic Plains, Black Soils, Soils of the Mountainous regions of the Himalayas and Red and Lateritic Soils of Peninsula.

NATURAL VEGETATION

Forests occupy about 19.4% of the total geographical area of the country against the ideal requirement of 33%. Based on the rainfall, temperature, altitude and land topography, natural vegetation of India has been classified into five major groups which have been further divided into 16 types, based on the entire enviro-vegetation complex (Annexures 1, 2). The tropical deciduous types (both moist and dry) constitute about 70% of the total forest vegetation. The vegetation diversity of India is briefly described in the chapter 8 on *Degraded and Wastelands Status in different Areas*.

GENERATION OF INPUT DATASETS

4

DATA SOURCE

To harmonize relevant thematic spatial datasets on the degraded and wastelands, generated by different organizations, it is essential to bring these databases to a single platform in the GIS for further processing. The thematic databases generated by the various agencies are presented in Table 6.

Table 6. Datasets generated by different organizations for mapping land degradation

Theme/Dataset	Data source and organization	Method of preparation/ criteria	Year of publication
Water Erosion	Soil Loss Map of India – NBSS&LUP and CSWCR&TI	Interpolation of 10 km x 10 km grid data of Soil Resource Map of India	2007
Wind Erosion	Wind Erosion–CAZRI and NBSS&LUP	Field surveys	2007
Acid Soils	Acid Soil Map of India– NBSS&LUP	Derived from 1 : 250,000 scale of Soil Resource Map of India	2005
Salt-affected Soils	Soil Salinity Map–CSSRI, NBSS&LUP and NRSA	Visual interpretation of satellite data with adequate ground checks	2004
Forest Cover	Forest Cover Map of India – FSI	Visual interpretation of satellite data with adequate ground checks	1999
Physical Degradation (Barren rocky/stony waste, waterlogged, snow-covered area/ice caps and mining and industrial wastelands)	Wasteland Map of India– NRSA	Visual interpretation of satellite data with adequate ground checks	2003

Sources: CAZRI, NBSS&LUP, CSSRI, NRSA, FSI

A brief description of the various datasets is presented as follows.

Water Erosion

This is the most widespread form of degradation and occurs widely in all agroclimatic zones of India. Soil material displacement by water can result either

Table 7. Statewise* area under different soil loss classes due to water erosion (> 10 tonnes/ha/yr)

State	TGA (km²)	Moderate [10–15] (tonnes/ha/yr)		Mod.Severe [15–20] (tonnes/ha/yr)		Severe [20–40] (tonnes/ha/yr)		Very Severe [40–80] (tonnes/ha/yr)		Extr.Severe [> 80] (tonnes/ha/yr)		Total area for different classes (km²)	Area (%)
		Area (km²)	Area (%)	Area (km²)	Area (%)	Area (km²)	Area (%)	Area (km²)	Area (%)	Area (km²)	Area (%)		
Andhra Pradesh	275,045	36,196	13	20,738	8	34,381	13	17,960	7			109,275	40
Arunachal Pradesh	83,743	4,271	5	4,539	5	19,805	24	22,870	27	9,354	11	60,839	73
Asom	78,438	3,592	5	14,182	18	11,632	15	22,198	28			51,604	66
Bihar	94,163	5,855	6	3,223	3	2,566	3	545	1			12,189	13
Chhattisgarh	134,805	10,771	8	8,695	6	24,561	18	18,360	14	25,640	19	88,028	65
Delhi	1,483	136	9	78	5	98	7	17	1			330	22
Gujarat	166,024	13,722	8	5,881	3	9,801	5	1,960	1			31,364	16
Haryana	44,212	1,136	3	553	1	809	2	420	1			2,918	7
Himachal Pradesh	55,673	3,023	5	2,088	4	4,120	7	3,196	6	5,612	10	18,038	32
Jammu and Kashmir	222,236	1,400	1	1,178	1	3,689	2	6,067	3	22,690	10	35,024	16
Jharkhand	79,714	12,424	16	9,140	11	16,739	21	9,748	12	3,699	5	51,750	65
Karnataka	191,791	51,784	27	21,097	11	17,261	9	3,836	2			93,978	49
Kerala	38,863	3,968	10	1,007	3	917	2	35	0			5,927	15
Madhya Pradesh	308,641	39,876	13	29,413	10	58,426	19	28,734	9	26,420	9	182,870	59
Maharashtra	307,713	30064	10	17,663	6	25,202	8	15,078	5	17,263	6	105,269	34
Manipur	22,327	3,405	15	2,552	11	5,941	27	0				11,898	53
Meghalaya	22,429	3,315	15	2,290	10	5,888	26	3,109	14	2,871	13	17,472	78
Nagaland	16,579	678	4	630	4	2,646	16	4,722	28	5,793	35	14,468	87
Orissa	155,707	16,007	10	10,417	7	14,854	10	6,571	4	1,619	1	49,468	32
Punjab	50,362	1,269	3	453	1	901	2	745	1			3,369	7
Rajasthan	342,239	26,250	8	15,811	5	27,790	8	13,347	4	6,571	2	89,769	26
Sikkim	7,096	64	1	84	1	555	8	776	11	1,137	16	2,616	37
Tamil Nadu	130,058	14,020	11	6,048	5	5,397	4	195	0			25,660	20
Tripura	10,486	745	7	734	7	682	7	902	9	965	9	4,027	38
Uttar Pradesh	238,568	66,480	28	23,984	10	19,910	8	32,397	13			142,772	59
Uttarakhand	55,845	4,114	8	3,757	6	4,931	9	18,267	33			31,069	58
West Bengal	88,752	10,553	12	3,763	4	3,257	4	346	0			17,919	20
Total	3,222,922	365,118	258	209,998	167	322,760	282	232,401	236	129,633	145	1,259,910	39

Note: *, Andaman and Nicobar Islands, Goa and Mizoram have not been evaluated
Sources: NBSS&LUP and CSWCR&TI

in loss of top-soil or in terrain deformation or both through the processes of splash erosion, sheet erosion, rill erosion and gully erosion. Soil erosion starts with the falling of the raindrops onto the bare soil surface. The impact of raindrops breaks-up surface soil aggregates and splashes particles into the air. On sloping land, detached soil material flows with runoff, down the slope, resulting in soil loss. The extent and the severity of the erosion is a function of the intensity of rainfall, land slope, soils and land use. Studies on the soil loss in various agro-ecological regions under various land uses were carried out by the CSWCR&TI over a long period. A variety of soil erosion prediction models are available in the literature, and have been validated and calibrated; and at present it is possible to make an assessment of soil losses at the country's level.

Soil loss assessment for different states has been carried out under a collaborative project between the National Bureau of Soil Survey and Land-Use Planning (NBSS&LUP), Nagpur, and the Central Soil and Water Conservation Research and Training Institute (CSWCR&TI), Dehra Dun. In this study, soil data collected by the NBSS&LUP at 10-km grid during Soil Resource Mapping (SRM) Project was used. Using an empirical Universal Soil Loss Equation (USLE), the point data was interpolated using interpolation techniques in SPANS GIS to estimate spatial variations of soil loss factors (R, K, LS, C, and P factors). These

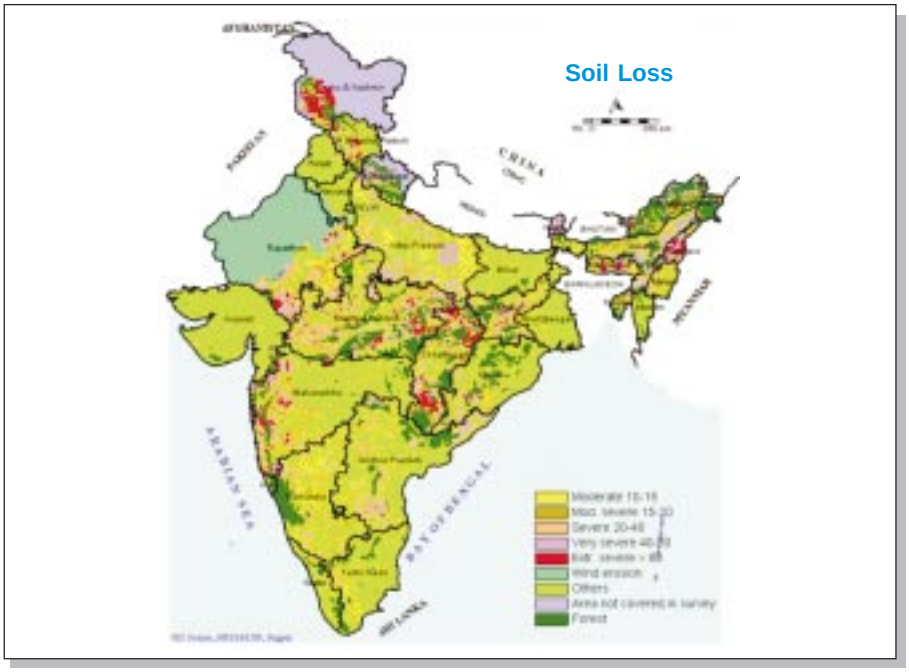

Fig. 1. Soil loss by water erosion in India (>10 tonnes/ha/yr)
Source: Maji *et al*. 2008

factors were integrated in the GIS to assess soil losses and their spatial extent for different states (except Goa and Mizoram). Soil loss values were categorized into five classes (moderate, moderately severe, severe, very severe and extremely severe), and statewise areas under different categories have been determined and mapped (Fig. 1; Table 7). An area of about 126 M ha has been found suffering from various degrees of water erosion.

Wind Erosion

This type of erosion basically involves displacement of soil particles by the action of wind. Normally the soil is removed in thin layers as sheet erosion, but sometimes wind effect can carve out hollows and other features. Wind erosion is a function of wind velocity, soil characteristics and land use. Wind displaces fine to medium size sand particles. The land degradation due to wind erosion is limited to arid regions of India (Fig. 2). Experimental studies on wind erosion under different land uses were conducted by the CAZRI, Jodhpur, and different parameters have been standardized for wind erosion. An area of 11 M ha is found suffering from wind erosion of various intensities. Very severe and severe wind erosion occur in 16% of the total geographical area (TGA) of the country. Moderate wind erosion occurs in 32% of TGA (Fig. 2)

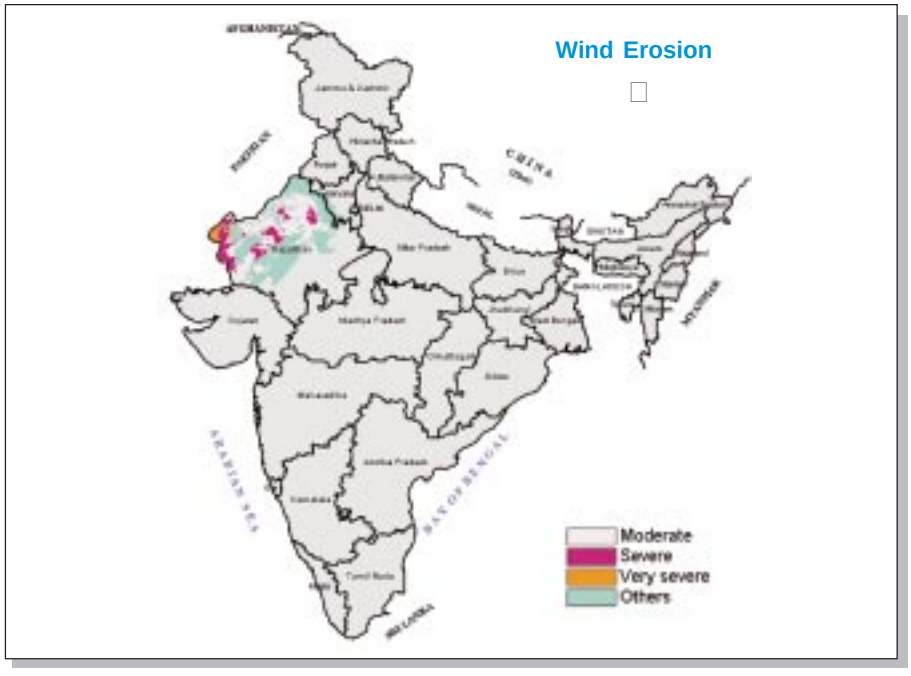

Fig. 2. Wind erosion in India (>10 tonnes/ha/yr)
Sources: CAZRI and NBSS&LUP. 2008, unpublished

Acid Soils

These soils develop in humid and per-humid areas due to excessive leaching of cations with high rainfall, resulting in lowering of *p*H and loss of soil fertility, and can be reclaimed by addition of chemical amendments like lime. For assessing area under acid soils, soil maps of different states on 1 : 250,000 scale were digitized in the GIS format. The non-spatial (attribute) data on *p*H values were linked to master soil layer to generate soil reaction (*p*H) map of India, which was reclassified to produce a soil acidity map of India. The acidity map of India, thus produced, facilitates understanding of spatial distribution and *p*H status of soils in different parts of India. Based on the range of *p*H values, the map has been reclassified as strongly acidic (*p*H < 4.5); moderately acidic (*p*H 4.5–5.5); slightly acidic (*p*H 5.5–6.5) and non-acidic (pH > 6.5).

However, for the estimation of the degraded lands of India, only strongly acidic - *p*H < 4.5 and moderately acidic – *p*H 4.5–5.5 soils have been considered. Accordingly Figure 3, depicts area covered by acid soils having *p*H < 5.5. About 6.98 M ha are affected by acid soils; which is about 9.4% of the total geographical area of the country.

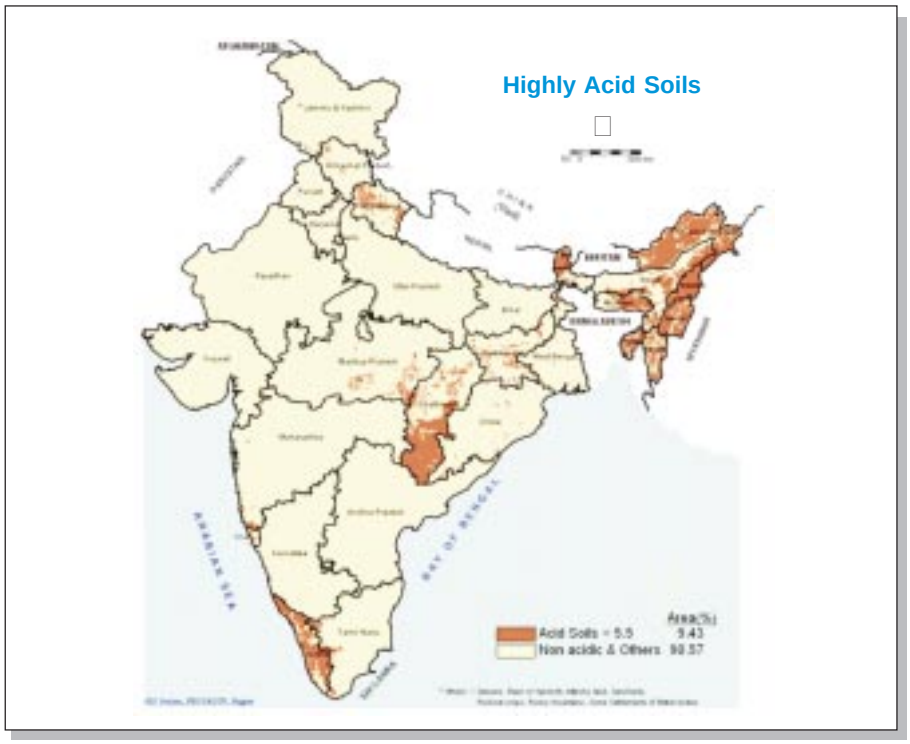

Fig. 3. Acid soils of India
Source: Maji *et al.* 2008a

Salt-affected Soils

These soils contain excessive amount of either soluble salts or exchangeable sodium or both affecting crop yields and crop production. Depending upon the physiochemical properties and the nature of the salts, the soils are classified into saline, sodic and saline-sodic. These soils appear in different shades of white tone with fine to coarse texture on the False Colour Composite (FCC) prints of the satellite data, owing to presence of the salts, and are recognizable under normal crop growth. For assessing these soils, the National Remote Sensing Agency has prepared maps on 1 : 250,000 scale using satellite data from Landsat TM/IRS sensors in association with other central and state government organizations (Table 8). Information on the salt-affected soils provided by the CSSRI, Karnal, was used for the harmonization of the degraded wasteland datasets of India. Salt-affected soils were regrouped into two classes namely saline and sodic soils in the GIS format. The harmonized areas under saline and alkaline soils are presented in Figure 4 and Table 8.

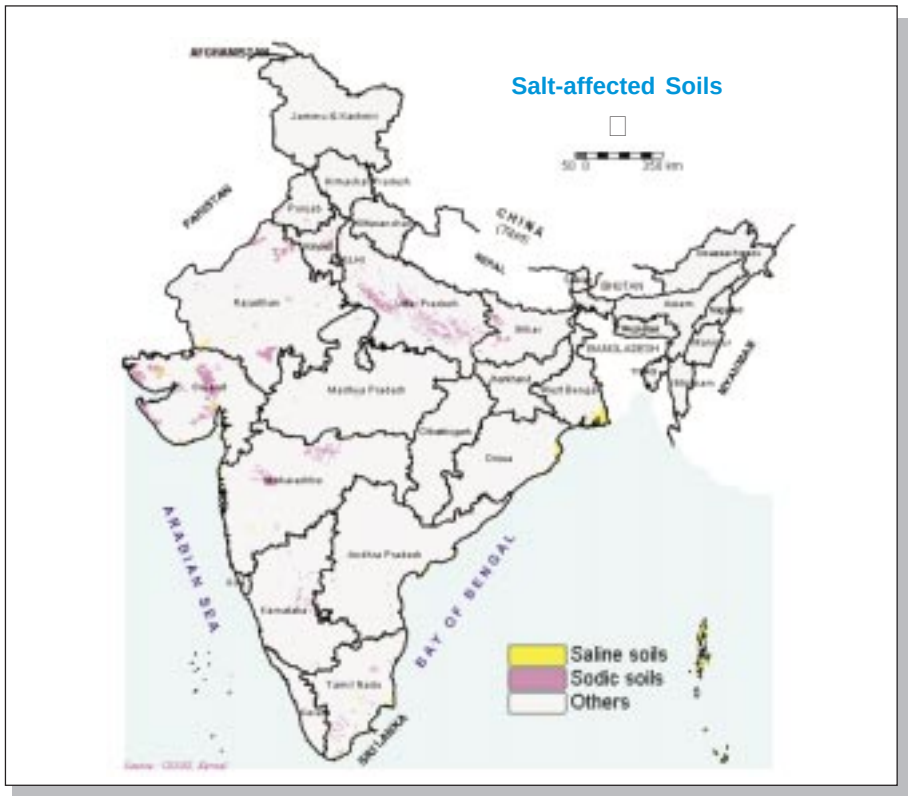

Fig. 4. Salt-affected soils of India
Source: CSSRI, Karnal

Table 8. Salt-affected soils by remote-sensing (based on 1986/87 satellite data with adequate field checks)

State	Saline soils (ha)	Sodic soils (ha)	Total (ha)
Andhra Pradesh	77,598	196,609	274,207
Andaman and Nicabar Islands	77,000	0	77,000
Bihar	47,301	105,852	153,153
Gujarat	1,680,570	541,430	2,222,000
Haryana	49,157	183,399	232,556
Karnataka	1,893	148,136	150,029
Kerala	20,000	0	20,000
Maharashtra	184,089	422,670	606,759
Madhya Pradesh	0	139,720	139,720
Orissa	147,138	0	147,138
Punjab	0	151,717	151,717
Rajasthan	195,571	179,371	374,942
Tamil Nadu	13,231	354,784	368,015
Uttar Pradesh	21,989	1,346,971	1,368,960
West Bengal	441,272	0	441,272
Total	2,956,809	3,770,659	6,727,468

Source: Sharma, R.C., Rao, B.R.M. and Saxena R.K. 2004

Forest Cover

It is estimated at 63.73 M ha, and it constitutes about 19.4% of the total

Fig. 5. Forest cover of India
Source: FSI, 1999

geographical area of the country (FSI, 1999). Out of the total, 37.7 M ha (11.5%) is under dense forest (canopy >40%) (Fig. 5). The same has been considered for the soil loss and acid soils estimation in the forest areas.

Physical Degradation

Land degradation by physical processes is classified as barren rock and stony wastelands, mining and industrial wastelands, snow-covered and ice-caps and waterlogged areas. This information has been generated by the NRSA using satellite data (Fig. 6). An area of 13.8 M ha is affected by physical degradation.

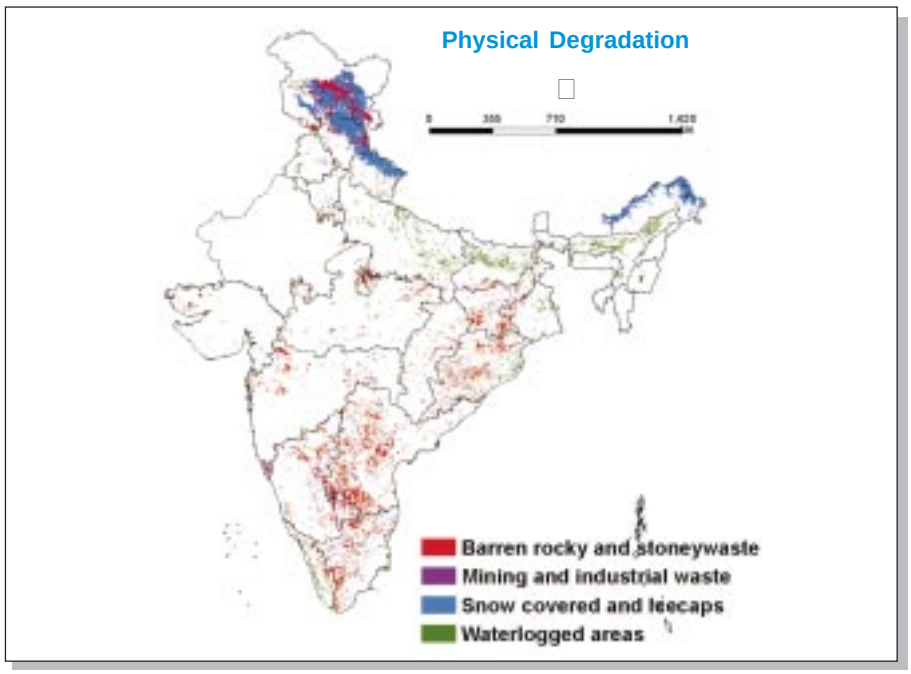

Fig.6. Physical land degradation in India
Source: NRSA. 2005

5 METHODOLOGY

The harmonization process for producing realistic estimates on the degraded and wastelands was thoroughly discussed by the National Remote Sensing Agency (now NRSC), Natural Resource Management institutes of the ICAR, scientists of the NAAS and other stakeholders in three, 2-day workshops, held at the National Remote Sensing Agency, Hyderabad. Similarities and dissimilarities in the various maps and datasets produced by the various organizations were analyzed, and shortcomings in the status of the degraded and wastelands were pinpointed. The major difference was identified as the scale of maps. Some of the items of the duplicated areas, data sources and definitions were also harmonized. Some degradation classes not responsive to amendments or management were excluded. For example, theoretically any soil having *p*H of less than 7 is acidic, but responses to amendments and reclamation were observed in the soils having *p*H less than 5.5. Similarly, snow-covered land or glaciers were excluded. Ice-capped land may not have green vegetation but glaciers are precious; and are an important source of water and should not be treated as wastelands. In fact, there is a global concern for preventing excessive melting of glaciers for sustaining water supplies. Rocky areas by definition are not soils and are treated as degraded lands. But such lands are also a source of water for watershed development for supporting biological activities downstream. Forest land with more than 40% canopy has not been considered degraded during harmonization process. Soil erosion below 10 tonnes per hectare generally does not significantly affect productivity, and has not been counted as degraded wastelands. The harmonized estimates, therefore, have been derived from the point of view of the practicalities of the reclamation, amelioration and management for agricultural planning rather than for purely academic interest. This has been necessary for a realistic planning of the land reclamation, wasteland management, land-use planning and watershed management for the sustainable conservation agriculture.

The harmonization process was made possible by putting all datasets in the GIS-compatible format. In the GIS exercise, the spatial layers of water erosion (soil loss), salt-affected soils, acid soils, lands affected by wind erosion, dense

forested and open forest layers were considered. In the first step, the soil loss classes of >10 tonnes/ha/yr (10–15, 15–20, 20–40, 40–80 and >80 tonnes/ha/yr) were considered. These were grouped, and layer 1 was thereby generated. In this, soils loss classes of very slight (<5 tonnes/ha/yr) and slight (5–10 tonnes/

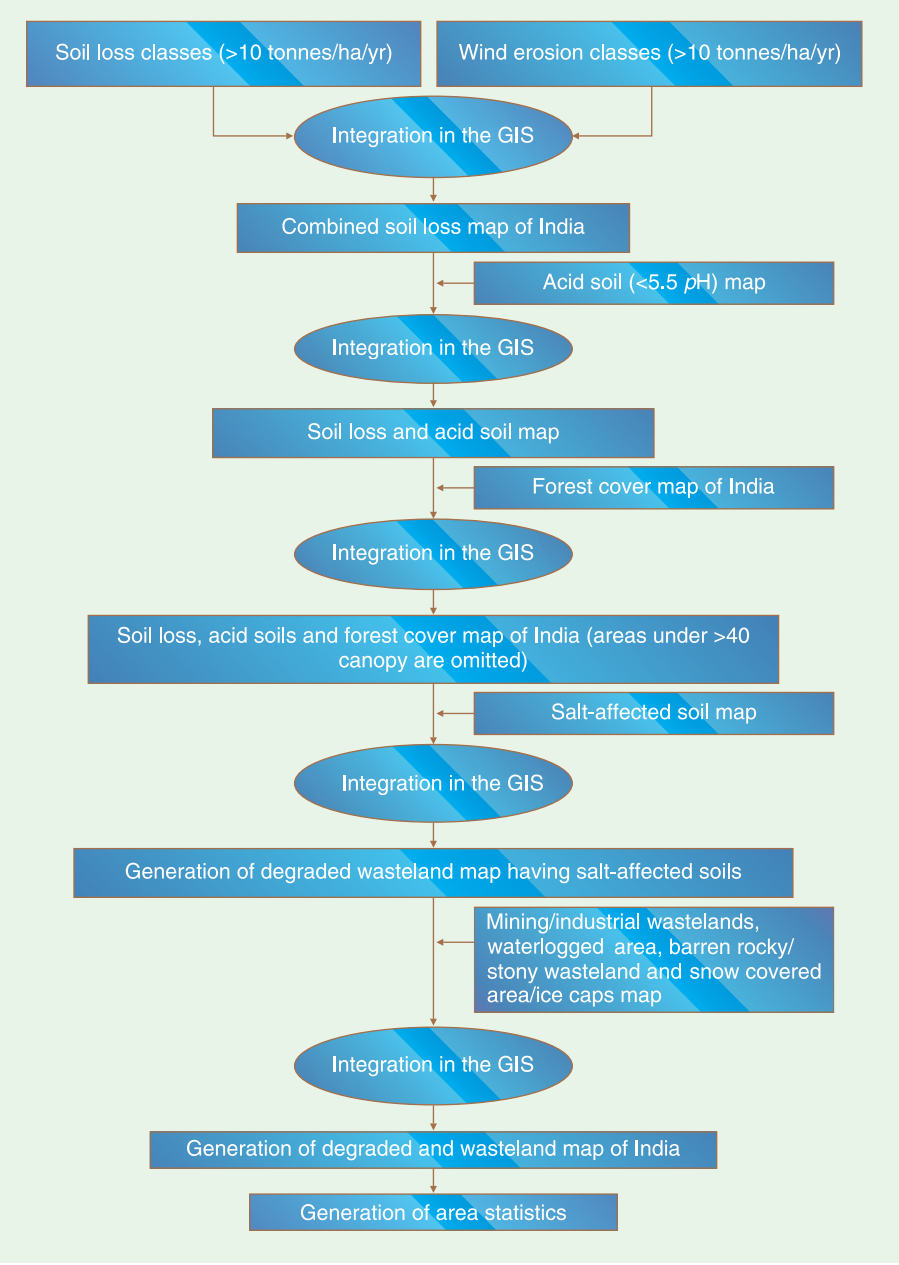

Fig. 7. Harmonization process

ha/yr) were not considered. As a second step, acid soil layer (<5.5 *p*H) was superimposed on the soil loss layer, and thus layer 2 was generated. In the third step, the wind erosion layer (moderate to extremely severe classes) was superimposed onto layer 2 and the layer 3 was generated. Since wind erosion areas do not fall either under dense and open forest cover, the total area remained the same. As the fourth step, the dense forest (>40% canopy) and open forest (<40% canopy) (FSI, 1999) were superimposed onto the layer 3, and areas of water erosion and acid soils coming under dense forest (>40% canopy) were deducted, and the land degradation classes associated with open forest were generated as a separate class, and layer 4 was generated. As the fifth step, the salt-affected layer having two classes (saline and sodic) were integrated with land degradation classes and all possible combination classes were identified to generate layer 5. As the next step, the physical degradation layers, like barren rock and stony wastelands, mining and industrial wastelands, snow-covered and ice caps and waterlogged areas assessed by the NRSA were integrated with other land degradation layers, and the final land degradation map of India with all possible combined classes was generated. These combined classes also denote areas with complex problems (more than one problem occurring in the same parcel of land). It should be noted that the harmonization procedure adopted above has a built-in standard deviation of ± 2%. The methodology described above is presented in the form of a flow chart followed for the harmonization procedure (Fig. 7).

6 SPATIAL DISTRIBUTION OF DEGRADED AND WASTELANDS

A harmonization exercise as described in the forgoing section has been done by developing a methodology involving various stakeholder organizations, and a final harmonized degraded and wastelands map of India with all possible combination classes has been generated (Fig.8). Degraded and wasteland areas under water, wind, physical and chemical degradations have been worked out

Table 9. Harmonized area statistics of degraded and wastelands of India

Degradation type	Arable land (M ha)	Open forest (<40% canopy) (M ha)	Data source
Water erosion (>10 tonnes/ha/yr)	73.27	9.30	Soil Loss Map of India–CSWCR&TI
Wind erosion (Aeolian)	12.40	–	Wind Erosion Map of India–CAZRI
Sub-total	85.67	9.30	
Chemical degradation			
Exclusively salt-affected soils	5.44	–	Salt-Affected Soils Map of India, CSSRI, NBSS&LUP, NRSA and others
Salt-affected and water eroded soils	1.20	0.10	
Exclusively acidic soils (pH< 5.5)#	5.09	–	Acid Soil Map of India NBSS&LUP
Acidic (pH < 5.5) and water eroded soils #	5.72	7.13	
Sub-total	17.45	7.23	
Physical degradation			
Mining and industrial waste	0.19		Wasteland Map of India–NRSA
Waterlogging (permanent surface inundation)$	0.88		
Sub-total	1.07		
Total	104.19	16.53	
Grand total (Arable land and open forest)	120.72		

Notes: Forest Survey of India Map (1999) was used to exclude degraded land under dense forest; Unculturable Wastelands: Barren rocky/stony waste: 6 M ha, are the source for runoff water and building material; Snow covered/Ice-caps: 6 M ha, are best source of water and are not treated as wastelands.
\# For acid soils, areas under paddy growing and plantation crops were also included in the total acid soils
$ Sub-surface waterlogging not considered.
Source: NBSS&LUP

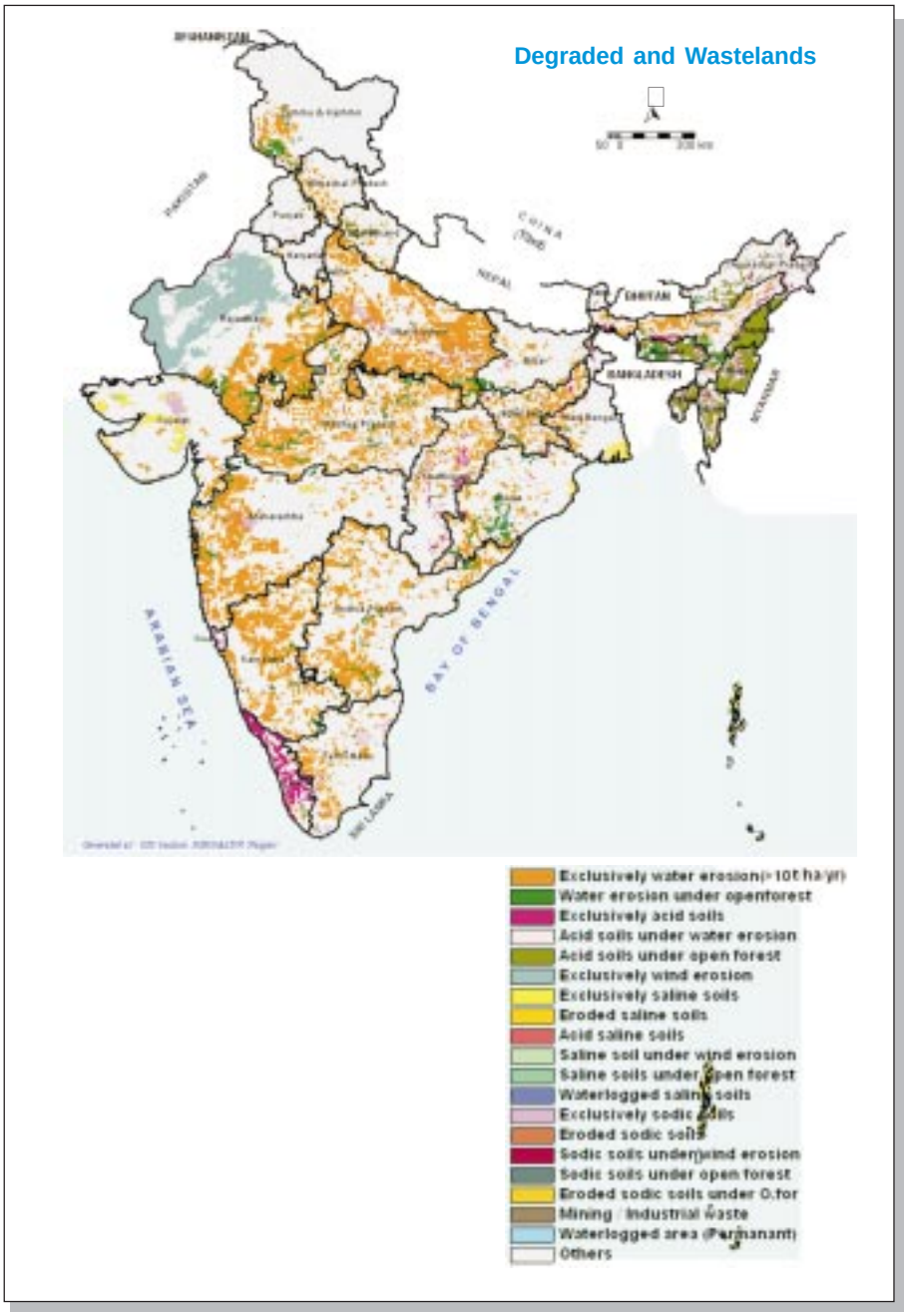

Fig. 8. Degraded and wastelands of India
Source: NBSS&LUP

(Table 9). Nineteen degradation classes have been identified and described, and area statistics under each class has been assessed (Table 10).

Table 10. Statewise area statistics of degraded and wastelands of India

State	TGA (km^2)	Degraded and wastelands classes* ('000 ha)								
		1	2	3	4	5	6	7	8	9
Andhra Pradesh	275,045	8,050	814	0	0.28	0	0	56	4	0
Andaman and Nicobar Islands	8,249	0.00	0	0	0.00	0	0	71	0	0
Arunachal Pradesh	83,743	165	215	300	501	968	0	0	0	0
Asom	78,438	1,929	437	411	1,319	265	0	0	0	0
Bihar	94,163	820	229	19	22	0.00	0	39	1	0
Chhattisgarh	134,805	2,347	75	812	1,383	147	0	0	0	0
Delhi	1,483	28	0	0	0	0	0	0	0	0
Goa	3,702	1	0	103	0	0	0	0	0	0
Gujarat	196,024	979	32	0	0	0	1	1,495	4	0
Haryana	44,212	303	0	2	0	0	0	44	2	0
Himachal Pradesh	55,673	941	43	34	41	1	0	0	0	0
Jammu and Kashmir	222,236	1,327	674	21	42	15	0	0	0	0
Jharkhand	79,714	2,825	356	226	394	115	0	0	0	0
Karnataka	191,791	7,450	349	69	24	0	0	2	0	0
Kerala	38,863	112	5	1,961	378	87	0	1	0	20
Madhya Pradesh	308,641	11,881	1,584	121	332	29	0	0	0	0
Maharashtra	307,713	8,400	422	41	228	0	0	164	7	0
Manipur	22,327	36	114	115	86	1,396	0	0	0	0
Meghalaya	22,429	127	579	52	175	796	0	0	0	0
Mizoram	21,081	0	0	150	0	1,013	0	0	0	0
Nagaland	16,579	1	30	17	45	1,454	0	0	0	0
Orissa	155,707	2,176	1,152	107	51	45	0	131	0	0
Punjab	50,362	228	74	0	0	0	0	0	0	0
Rajasthan	342,239	7,436	1,196	0	0	0	11,419	74	8	0
Sikkim	7,096	2	0	2	43	13	0	0	0	0
Tamil Nadu	130,058	2,063	71	161	216	50	0	10	1	0
Tripura	10,486	26	48	101	83	525	0	0	0	0
Uttar Pradesh	238,566	12,370	514	0	0	0	0	9	13	0
Uttarakhand	55,845	829	180	13	189	198	0	0	0	0
West Bengal	88,752	1,167	97	240	165	13	0	408	0	0
Others**	1,248							125		
Total	3,287,270	74,020	9,290	5,080	5,720	7,130	11,420	2,630	40	20

(continued)

(Table 10. concluded)

Degraded and wastelands classes* ('000 ha)										Total area of 1–19 classes ('000 ha)	State
10	11	12	13	14	15	16	17	18	19		
0	0	17	154	39	0	0	1	39	19	9,193	Andhra Pradesh
0	0	0	0	0	0	0	0	0	0	71	Andaman and Nicobar Islands
0	0	0	0	0	0	0	0	0	5	2,154	Arunachal Pradesh
0	0	0	0	0	0	0	0	0	210	4,571	Asom
0	0	5	98	8	0	0	0	2	128	1,371	Bihar
0	0	0	10	3	0	0	0	7	0	4,784	Chhattisgarh
0	0	0	0	0	0	0	0	0	0	28	Delhi
0	0	0	0	0	0	0	0	12	6	122	Goa
0	60	0	545	0	0	0	0	12	1	3,129	Gujarat
0	0	0	183	1	0	0	0	12	4	551	Haryana
0	0	0	0	0	0	0	0	1	4	1,065	Himachal Pradesh
0	0	0	0	0	0	0	0	1	14	2,094	Jammu and Kashmir
0	0	0	0	0	0	0	0	21	6	3,943	Jharkhand
0	0	0	97	48	0	0	0	51	3	8,093	Karnataka
0	0	1	0	0	0	0	0	1	43	2,608	Kerala
0	0	0	74	49	0	1	0	24	0	14,095	Madhya Pradesh
0	0	0	256	164	0	0	1	16	27	9,728	Maharashtra
0	0	0	0	0	0	0	0	0	21	1,768	Manipur
0	0	0	0	0	0	0	0	0	3	1,732	Meghalaya
0	0	0	0	0	0	0	0	0	0	1,163	Mizoram
0	0	0	0	0	0	0	0	0	3	1,550	Nagaland
0	0	6	0	0	0	0	0	8	46	3,722	Orissa
0	0	0	151	1	0	0	0	6	34	494	Punjab
110	0	0	108	26	30	1	16	0	0	20,424	Rajasthan
0	0	0	0	0	0	0	0	0	0	60	Sikkim
0	0	2	305	28	0	17	2	34	37	2,997	Tamil Nadu
0	0	0	0	0	0	0	0	0	25	785	Tripura
0	0	0	626	692	0	2	0	3	176	14,405	Uttar Pradesh
0	0	0	0	0	0	0	0	1	25	1,435	Uttarakhand
0	0	0	0	0	0	0	0	7	43	2,140	West Bengal
										125	Others**
110	60	30	2,610	1,060	30	20	20	260	860	120,402	Total

Notes: Classes*: **1** Exclusively water erosion (>10 tonnes/ha/yr); **2** Water erosion under open forest; **3** Exclusively acid soils (pH <5.5); **4** Acid soils under water erosion; **5** Acid soils under open forest; **6** Exclusively wind erosion; **7** Exclusively saline soils; **8** Eroded saline soils; **9** Acid saline soils; **10** Saline soils under wind erosion; **11** Saline soils under open forest; **12** Waterlogged saline soils; **13** Exclusively sodic soils; **14** Eroded sodic soils; **15** Sodic soils under wind erosion; **16** Sodic soils under open forest; **17** Eroded sodic soils under open forest;**18** Mining/Industrial waste; **19** Waterlogged area (Permanent)
Others**: Chandigarh, Dadar and Nagar Haveli, Daman and Diu, Lakshadweep and Puducherry
Source: NBSS&LUP

7 AGRO-ECOREGIONS AND LAND DEGRADATION

Land, agriculture and ecology are intrinsically related and govern our agricultural systems holistically. Climatic factors such as temperature, rainfall, humidity, sunshine and wind are the primary determinants of climate of any region. And climate and soil interactions provide suitable environment for agricultural production, and also affect physical processes of land degradation. To conserve natural resources for sustainable food production, an inclusive approach is needed to create relatively homogeneous regions in terms of soil, climate and physiography, termed as agro-ecological regions. Delineation of such regions will help understanding of agricultural potentialities of the regions for different land uses and also for conservation of their physical environment.

Agroclimatic region is the land unit in terms of major climate, superimposed on length of growing period (moisture availability period), and an agro-ecological zone is the land unit carved out of the agroclimatic region, superimposed on the landform, which acts as a modifier to climate and length of growing period (Sehgal and Abrol, 1994).

To understand implications and role of climatic and edaphic resources in agricultural and allied sectors, the NBSS&LUP prepared an agro-ecological map, based on the physiography, soils, bioclimate and length of growing period (GP), and refined it through several approximations. The data from 474 meteorological stations were used for preparing water balances (Thornthwaite and Mather, 1955). Length of growing period (LGP) was calculated using FAO (1983) model, adopted after Higgins and Kassam (1981). The GP as per the model starts when precipitation (P) exceeds 0.5 potential evapotranspiration (PET) and ends with utilization of 100 mm of stored soil moisture once P falls below PET. Growing period values for 474 observation sites were plotted and isolines were drawn at 30 days intervals. It has been observed that arid regions generally correspond with growing period of less than 90 days and semi-arid region with 90–150 days. Subhumid zone has GP more or less between 150 and 210 days. Humid and per-humid zones correspond with GP of 210 to 270 days and more than 270 days per year.

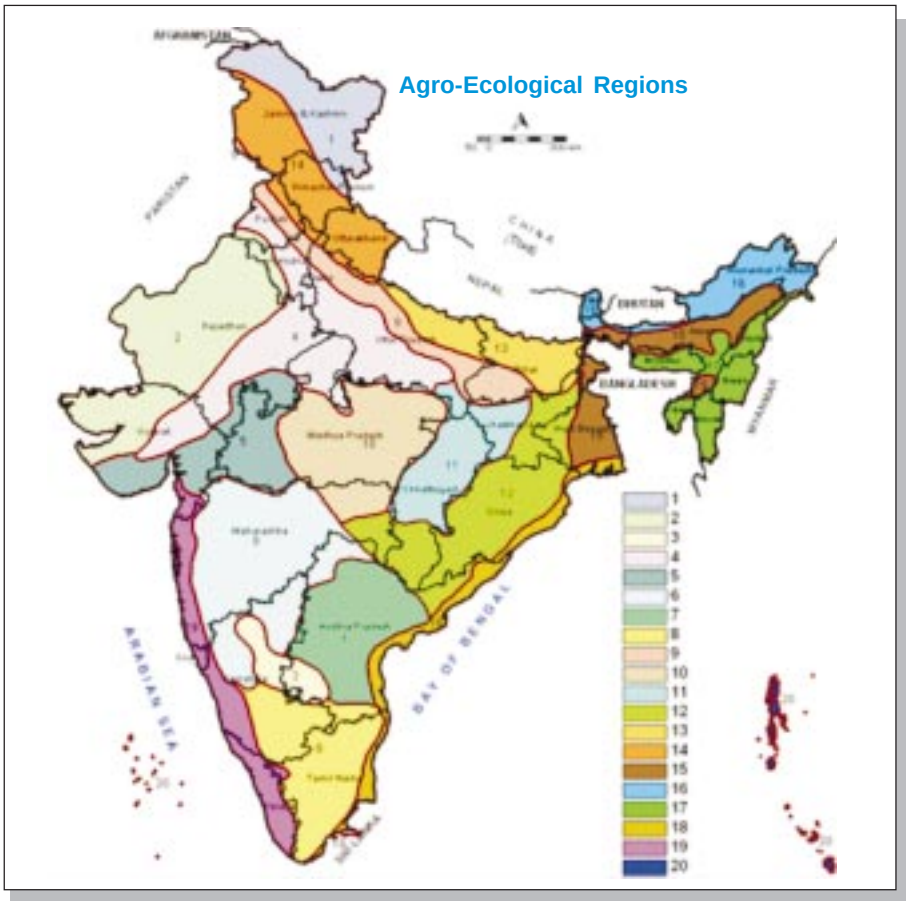

Fig. 9. Agro-ecological regions (AERs) of India; (**1** Western Himalayas cold arid ecoregion, with shallow skeletal soils and length of growing period (GP) <90 days; **2**. Western plain, Kachchh and part of Kathiawar peninsula, hot arid ecoregion, with desert and saline soils and GP <90 days; **3**. Deccan plateau, hot arid ecoregion, with red and black soils and GP <90 days; **4**. Northern plain and central highlands including Aravallis, hot semi-arid ecoregion, with alluvium derived soils and GP 90–150 days; **5** Central (Malwa) highlands, Gujarat plains and Kathiawar peninsula, hot semi-arid ecoregion, with medium and deep black soils and GP 90–150 days; **6** Deccan plateau, hot semi-arid ecoregion, with shallow and medium (with inclusion of deep) black soils and GP 90–150 days; **7** Deccan (Telangana) plateau and Eastern Ghats, hot semi-arid ecoregion, with red and black soils and GP 90–150 days; **8** Eastern Ghats, Tamil Nadu uplands and Deccan (Karnataka) plateau, hot semi-arid ecoregion, with red loamy soils and GP 90–150 days; **9** Northern plain, hot sub-humid (dry) ecoregion, with alluvium derived soils and GP 90–150 days; **10** Central Highlands (Malwa, Bundelkhand and Eastern Satpura), hot sub-humid ecoregion, with black and red soils and GP 150–180 (to 210) days; **11** Eastern plateau (Chhattisgarh), hot subhumid ecoregion, with red and yellow soils and GP 150–180 days; **12** Eastern (Chhotanagpur) plateau and Eastern Ghats, hot subhumid ecoregion, with red and lateritic soils, and GP 150–180 (to 210) days; **13** Eastern plain, hot subhumid (moist) ecoregion, with alluvium derived soils and GP 180–210 days; **14** Western Himalayas, warm subhumid (to humid with inclusion

(contd on p. 30 bottom)

Agro-ecological regions map was prepared by superimposing bioclimatic-cum-growing period map over the base soil-scape map (soil + physiography) on 1 : 4 m scale. Derived homogeneous units were delineated, adjusting boundaries with the district boundaries to arrive at the agro-ecological regions map. On the basis of the procedure followed, the country has been broadly grouped into 20 agro-ecological regions (Sehgal *et al.*, 1992) (Fig. 9; *see* Annexure 1).

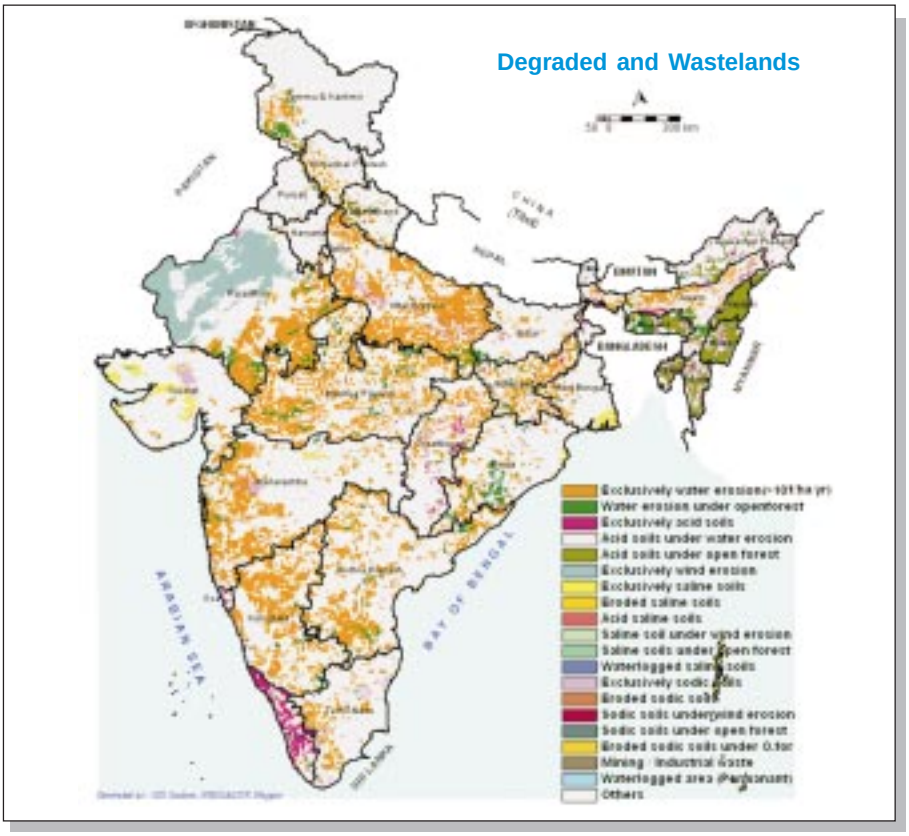

Fig. 10. Degraded and wastelands in the Agro-ecological regions of India
Source: NBSS&LUP

per-humid) ecoregion, with brown forest and podzolic soils and GP 180–210+ days; **15** Bengal and Asom plain, hot subhumid (moist) to humid (inclusion of per-humid) ecoregion, with alluvium derived soils and GP 210+ days; **16** Eastern Himalayas, warm per-humid ecoregion, with brown and red hill soils and GP 210+ days; **17** North-Eastern Hills (Purvanchal), warm perhumid ecoregion, with red and lateritic soils and GP 210+ days; **18** Eastern Coastal plain, hot subhumid to semi-arid ecoregion, with coastal alluvium derived soils and GP 90–210+ days; **19** Western Ghats and Coastal plain, hot humid–per-humid ecoregion, with red, lateritic and alluvium derived soils and GP 210+ days; **20** Islands of Andaman-Nicobar and Lakshadweep, hot humid and perhumid island ecoregion, with red loamy and sandy soils and GP 210+ days.
Source: Sehgal *et al.*, 1992

Table 11. Area under degraded and wastelands of India under different AERs

AERs	Degraded and wastelands classes* ('000 ha)																			Total degraded area ('000 ha)
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	
1	19	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	19
2	638	123	0	0	0	11,419	1,106	6	0	110	60	0	405	1	30	0	0	8	7	13,913
3	2,341	76	0	0	0	0	1	0	0	0	0	0	75	47	0	0	0	20	0	2,560
4	12,109	1,024	0	1	0	6	367	7	0	0	0	0	929	423	0	1	11	14	68	14,960
5	6,455	983	3	22	0	0	184	2	0	0	0	0	25	15	0	0	5	6	0	7,700
6	10,374	257	0	0	0	0	171	6	0	0	0	0	269	175	0	0	1	17	0	11,270
7	4,376	465	12	7	0	0	0	0	0	0	0	0	79	15	0	0	1	31	0	4,986
8	4,412	391	272	151	60	0	3	1	0	0	0	0	287	36	0	17	2	48	5	5,685
9	3,122	378	3	3	0	0	2	3	0	0	0	0	368	293	0	2	0	9	89	4,272
10	6,934	822	119	308	28	0	0	0	0	0	0	0	35	20	0	1	0	21	0	8,288
11	3,843	514	653	726	159	0	0	0	0	0	0	0	11	3	0	0	0	16	0	5,925
12	4,917	1,512	469	1,089	142	0	2	0	0	0	0	0	0	0	0	0	0	38	24	8,193
13	3,803	48	41	41	0	0	40	9	0	0	0	5	2	24	0	0	0	1	163	4,177
14	4,009	1,025	75	289	222	0	0	0	0	0	0	0	10	0	0	0	0	4	61	5,695
15	2,011	213	647	1,229	328	0	64	0	0	0	0	0	0	0	0	0	0	1	242	4,735
16	576	229	275	651	782	0	0	0	0	0	0	0	0	0	0	0	0	0	10	2,523
17	210	992	439	516	5,330	0	0	0	0	0	0	0	0	0	0	0	0	1	31	7,519
18	928	48	43	12	3	0	574	4	0	0	0	25	115	6	0	0	0	10	83	1,851
19	2,944	187	2,029	674	76	0	40	1	20	0	0	0	0	0	0	0	0	15	76	6,062
20	0	0	0	0	0	0	77	0	0	0	0	0	0	0	0	0	0	0	0	77
Total	74,021	9,287	5,080	5,719	7,130	11,425	2,631	39	20	110	60	30	2,610	1,058	30	21	20	260	859	120,410

Note: Classes*: **1**. Exclusively water erosion (>10 tonnes /ha/yr); Water erosion under open forest, **2**. Forest; **3**. Exclusively acid soils (pH <5.5); **4**. Acid soils under water erosion; **5**. Acid soils under open forest; **6**. Exclusively wind erosion; **7**. Exclusively saline soils; **8**. Eroded saline soils; **9**. Acid saline soils; **10**.Saline soils under wind erosion; **11**. Saline soils under open forest; **12**.Water logged saline soils; **13**. Exclusively sodic soils; **14**.Eroded sodic soils; **15**. Sodic soils under wind erosion; **16**. Sodic soils under open forest; **17**. Eroded sodic soils under open forest; **18**.Mining / Industrial waste; **19**. Waterlogged area (Permanent)

Source: NBSS&LUP

To understand the distribution of degraded and wastelands in different agro-ecoregions, the agro-ecoregion map was superimposed on the degraded and wastelands map (Fig. 10), and areal statistics was worked out.

The area estimates of the degraded and wastelands in different AERs (Table 11) reveal that region 4 is highly degraded with area coverage of 14,960 thousand ha. The other AERs having appreciably high area coverage are AER-2 (13,913 thousand ha), AER-5 (11,270 thousand ha), AER-10 (8,288 thousand ha), AER-12 (8,193 thousand ha), and AER-17 (7,519 thousand ha). Though all the AERs are affected but the least affected are AER-1 and AER-20.

Water erosion (classes 1, 2) has affected almost all AERs and AERs with large affected areas are: AER-4 (13,133 thousand ha), AER-6 (10,631 thousand ha), AER-5 (7,438 thousand ha), AER-12 (6,429 thousand ha), AER-14 (5,034 thousand ha), AER-7 (4,841 thousand ha) and AER-8 (4,803 thousand ha). Least affected AERs are AER-20, AER-1 and AER-17. Soil acidity (classes 3,4,5) has been observed in all AERs, excepting AER-1, AER-2, AER-3 and AER-20. Very little land areas are affected in AER-4 and AER-6. Highly affected AERs are AER-17 (6,285 thousand ha), AER-19 (2,779 thousand ha), AER-15 (2,204 thousand ha), AER-12 (1,700 thousand ha) and AER-11 (1,538 thousand ha).

Salinity affected (classes 7,8,9,10,11,12) agro-ecological regions are located in the semi-arid and sub-humid climatic zones of the country. Highest area coverage with salinity is in AER-2 (1,282 thousand ha), followed by AER-18 and AER-4 with 603 and 374 thousand ha, respectively.

Sodicity and salinity are observed in combination in some of the AERs. Notable among them are AER-2, AER-4, AER-6 and AER-18. Agroclimatic conditions coupled with management practices (including irrigation) are the main reasons for the development of soil sodicity. Highest sodicity (classes 13,14,15,16,17) is observed in AER-4 (1,364 thousand ha), followed by AER-9 (663 thousand ha), AER-6 (445 thousand ha), AER-2 (436 thousand ha), AER-8 (342 thousand ha), and it is not a problem in AER-1, AER-11, AER-12, AER-15, AER-16, AER-17, AER-19 and AER-20.

Wind erosion (class 6) is predominant in AER-2 and has a little affected area in AER-4.

DEGRADED AND WASTELANDS STATUS IN DIFFERENT AREAS

8

For planning, reclamation/conservation and ameliorative measures for the restoration of the degraded and wastelands, it is necessary to have their spatial extent at the state and district levels. Keeping this in view, the national degraded wasteland map has been utilized to generate area statistics of various states and their districts. A brief description of the states, their geographical setting and land degradational statistics is presented here.

NORTH-EASTERN REGION

The North- Eastern Region comprises Arunachal Pradesh, Asom, Meghalaya, Manipur, Mizoram, Nagaland, Tripura and Sikkim.

Arunachal Pradesh

Location

Arunachal Pradesh is situated between 26°30 to 29°28 N latitudes and 91°25 to 97°24 E longitudes and covers 8.37 M ha (275, 045 km^2). It is bounded by China in the north, Asom in the south, Myanmar and Nagaland in the east and Bhutan in the west.

Physiography

The state can be broadly divided into four distinct physiographic regions: the greater Himalayan range with snow-capped mountains with altitudes rising to 5,500 m above mean sea level (msl), the lower Himalayan ranges up to an altitude of 3,500 m above msl; the Sub-Himalayan belt including Siwalik hills with altitude up to 1,500 m above msl and the plains of the eastern continuity of Asom.

The greater Himalayas with snow-capped mountains cover districts of Lohit, Dibang valley, East Siang and West Siang, Lower and Upper Subansiri, East Kameng and West Kameng. The lower and the central Himalayas include Siwalik or sub-Himalayan range with moderately steep to steep hills. Sub-Himalayan belt includes southern part of the hill ranges along Kameng, Subansiri and West Siang. The plains are continuity of Asom plains, including plains of the Lohit, Tirap, Dibang and Siang rivers.

Geology

It is characterized by sedimentary and metamorphic rocks. Some important rock groups are Sela, Tenga and Bichom.

Sela consists of schists, magnetites, quartzites and amphiboles. Tenga formations are of low-grade metamorphic rocks like schists, amphiboles, phyllites, sericites and quartzites, and Bichom are sedimentary rocks, quartzites, phyllites, shales, sandstone. Dolomites are also found in the state.

Different types of metamorphic rocks and volcanic extrusions of much older age predominate northern part. The rock formations of Lohit and Dibang valley districts on the south-western part comprise a narrow stretch of sedimentary rocks of Tertiary period that consist of sandstone, shale, clay and pebble beds.

Climate

Its climate is humid to per-humid subtropical, characterized by high rainfall and high humidity at the sub-Himalayan belt. Average annual rainfall varies from 1,380 to 5,000 mm, and the minimum temperature is around 0°C in winter months in Bomdila and Twang areas and rises to 35°C during summer months in Namsai and Tezu areas of Lohit district. In plains, mean annual air temperature is 23.8°C and in hilly regions, it is 16.2°C.

Natural Vegetation

This is of open scrub (grassland) to alpine forests types in the greater Himalayas. Sub-alpine and alpine forest species in the greater Himalayan region are represented by blue pine (*Pinus wallichiana*), and chir pine (*P. roxburghii*). Temperate and subtropical forests in the lower Himalayan region are of *deodar* (*Cedrus deodara*) and East Himalayan fir (*Abies densa*). And most common species of tropical rain forests and semi-evergreen forests are *hingori* (*Bhesa robusta*), *sal* (*Shorea robusta*), teak (*Tectona grandis*) and sissoo (*Dalbergia sissoo*). Besides trees, many of the shrubs, canes, palms, climbers, grasses are also found.

Soils

In Arunachal Pradesh, 79 soil families have been identified. These have been mapped into 45 soil units. Arunachal Pradesh soils belong to 4 orders, 10 suborders, 16 great groups and 31 subgroups. Inceptisols are dominant soils, followed by Entisols, Alfisols, Ultisols and miscellaneous land types (including rock outcrops and snow-covered mountains), occupying 37.3%, 35.6%, 0.3%, 14.2% and 12.6% of the total geographical area (Nayak *et al.,* 1996).

Land Use

About 62% of the total area of the state is under forests, and cultivated lands account for less than 2%. Land not available for cultivation accounts for 0.4%, fallow land covers 2% and other uncultivated lands, excluding fallow land, account for 2%.

Shifting cultivation known as '*Jhuming*' is still practised extensively on the hill slopes of most of the districts, and about 0.25 M ha is under *jhum* cultivation. Principal crops grown in the hilly region are paddy, maize, beans, potato. Different temperate fruits, apple, peach, kiwi-fruit, plum, are also grown, and the state also has tea and coffee plantations. In the sub-Himalayan belt and the foot hills, paddy is the main crop, followed by maize, beans and spices along with the horticultural crops, orange, banana and pineapple. In the plains, paddy is extensively cultivated in *kharif* and mustard, potato, wheat and all kinds of winter vegetables are grown in *rabi* season. Major cropping patterns are paddy-mustard, maize-pea, millets-potato, maize-barley, maize-vegetables, paddy-beans, maize-buckwheat and millets-mustard.

Degraded and Wastelands

The datasets of the state indicate that 165 thousand ha (1.9% of TGA) is exclusively affected by water erosion. Water erosion in the open forest area

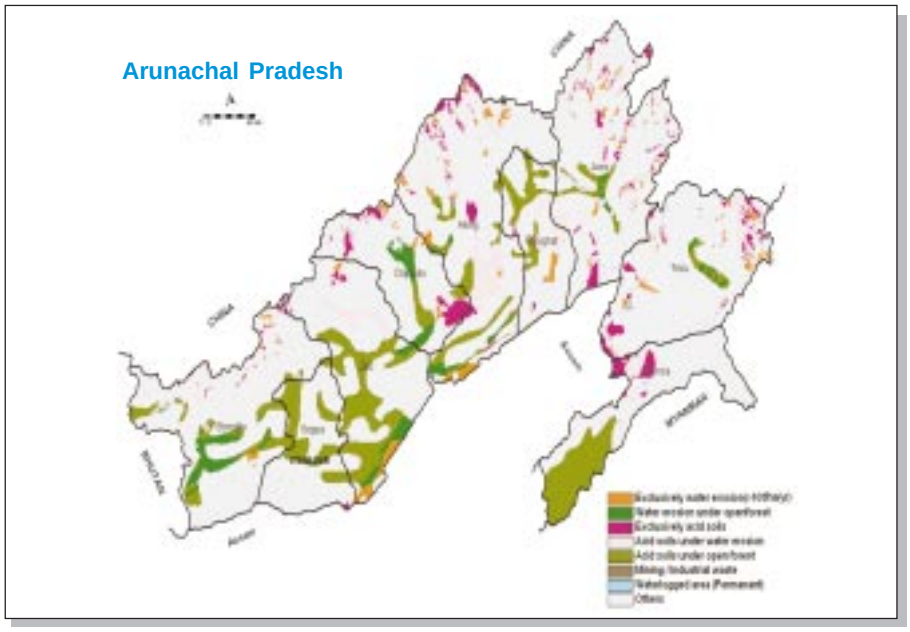

Fig. 11. Degraded and wastelands of Arunachal Pradesh
Source: NBSS&LUP, SRM Report, 1996

Table 12. Degraded and wastelands statistics of Arunachal Pradesh* (Area in '000 ha)

Districts (9)	Degraded and wastelands classes**								Others***	Total
	1	2	3	4	5	18	19	Total of classes		
Along	45	29	56	164	106	0	0	400	1,061	1,461
Anini	29	12	63	81	40	0	1	226	1,077	1,303
Bomdila	12	66	11	14	94	0	0	197	863	1,060
Daporijo	13	49	57	33	43	0	0	195	509	704
Khonsa	0	0	36	35	204	1	1	277	425	702
Pasighat	9	1	3	27	65	0	0	105	284	389
Seppa	1	0	3	0	140	0	0	144	416	560
Tezu	28	15	62	84	22	0	3	214	926	1,140
Ziro	28	43	9	63	254	0	0	397	658	1,055
Total	165	215	300	501	968	1	5	2,155	6,219	8,374

Notes: *, Districts are shown as per the Soil Resource Mapping of Arunachal Pradesh Report
Classes**: **1** Exclusively water erosion (>10 tonnes/ha/yr); **2** Water erosion under open forest; **3** Exclusively acid soils; **4** Acid soils under water erosion; **5** Acid soils under open forest; **18** Mining/Industrial waste; **19** Waterlogged area (Permanent)
Others***: Normal agricultural lands, water-bodies, rivers, lakes and habitats etc. (based on the limited reconnaisance survey)
Source: NBSS&LUP

(<40% canopy cover) is 215 thousand ha (2.5% of TGA). Acid soils (having *p*H <5.5) cover about 300 thousand ha (3.5% of TGA). Acidic soils with problems of water erosion account for 501 thousand ha (5.9% of TGA). Total acid soils (all categories) amount to 1,769 thousand ha, which are about 21% of TGA. Mining waste lands and waterlogged areas are minimal (Fig. 11; Table 12).

Water erosion (exclusive and in open forest areas) has affected Bomdila, Along, Ziro, Daporijo and Tezu districts. Along district has larger area under acid soils, followed by Tezu and Anini. Total degraded and wastelands cover largest area in Along, followed by Anini, Tezu, Bomdila and Ziro. Tezu has waterlogged area of 2.6 thousand ha and Khonsa has 1.4 thousand ha.

Districts having highest amount of degraded and wastelands are Along (400 thousand ha), Ziro (397 thousand ha), followed by Anini (226 thousand ha) Tezu (214 thousand ha) and Bombila (197 thousand ha).

Asom

Location

Asom is situated in the central valley region of the North-Eastern Region of India. Its total area is 7.8 M ha (78,438 km^2). It is bounded by two foreign countries and seven Indian states. To the north, it borders Bhutan and Arunachal Pradesh. The eastern part is surrounded by Arunachal Pradesh, Nagaland and Manipur.

Southern boundary is shared by Mizoram and Meghalaya. West Bengal, Bangladesh and Tripura form the western boundary.

Physiography

The state has been divided into four physiographic regions: the Brahmaputra plain, the Barak plain, the Karbi plateau and the North Cachar Hills.

Brahmaputra valley is the continuity of the great Indo-Gangetic plain which separates sub-Himalayan foothills of Shillong plateau and Patkai Naga hills. It comprises '*bils*', oxbow lakes and marshy lands. Char, a unique land type, is very prominent in the Brahmaputra valley, and Majuli is the biggest river island of the world.

The Barak valley surrounding Karimganj area is level alluvial flat land. Central Asom range comprises hills of Karbi Anglong and North Cachar hills, an extension of Shillong plateau.

Geology

The geological history of the area has revealed that Archaean, the late Cretaceous, Tertiary and Quaternary formations are the predominant types in Asom. State geology is very complex, and is the product of an ancient landmass caught up in collision zones of three other landmasses, which were originally its neighbours, but drifted apart with the break up of the Gondwana land. Later these collided again to result present geological and continental framework. The Brahmaputra and Barak valleys are built up by the deposition of alluvium of several hundred metres depth. The Karbi plateau is dominated by Pre-cambrian rocks. The Barail range and Naga hills are dominated by Tertiary sandstones and related rocks.

Climate

Its climate is neither too cold in winter nor too hot in summer. In general, it is of subtropical type, influenced by the monsoon. The state receives high precipitation during June to August; and a small amount of rainfall is received during pre-monsoon (April and May) and post-monsoon (September and October). Rainfall is scanty in winter months from November to February. Lakhimpur and Cachar districts receive the highest amount of rainfall, while Nagaon and Karbi Anglong, the least. Average annual rainfall is 1,700 mm, and average annual temperature is about 24°C.

Natural Vegetation

Flora of the state is broadly divided into evergreen forests, mixed deciduous

forests, riverine forests and Savannah. Among the evergreen, the most common trees are: *hollong* (*Dipterocarpus macrocarpus*), *nahar* (*Mesua ferrea*), *gamari* (*Gmelina arborea*), *kadam* (*Anthocephalus cadamba*), *garidsarai* (*Cinnamomum cecidodaphne*), *dhuna* (*Canarium bengalense*), *konkon* (*Duabanga sonneratioides*), *sepa* (*Michelia champaca*), *silikha* (*Terminalia chebula*), *bhomora* (*Terminalia belerica*), *agaru* (*Aquilaria malaccensis*), and *bonsom* (*Phoebe attenuata*). Deciduous forest species are of *sal* (*Shorea robusta*), *digsa* (*Pinus keisya*), *sam* (*Artocarpus chaplasha*).

Soils

Its soils belong to 4 orders, 9 suborders, 15 great groups, 26 subgroups and 83 soil family associations. The Inceptisols are the dominant soils, followed by Entisols, Alfisols and Ultisols, which occupy 41.4%, 33.6%, 11.3% and 5.6% of the total geographical area of the state and miscellaneous land types are marshy and riverine, which total to 8.1% (Sen *et al.,* 1999).

Land Use

The principal crops in the upper Asom are tea and paddy, jute and paddy are in the middle Asom, and paddy is in the lower Asom. In some parts of the state, vegetables are cultivated. Nagaon and Marigaon are prominent vegetable-growing districts.

Agro-based tea industry is most significant in the state. Jorhat, Sibsagar and Golaghat districts are famous for tea-gardens, which produce about 52% of the country's total tea, and contribute towards about 10% of state's income.

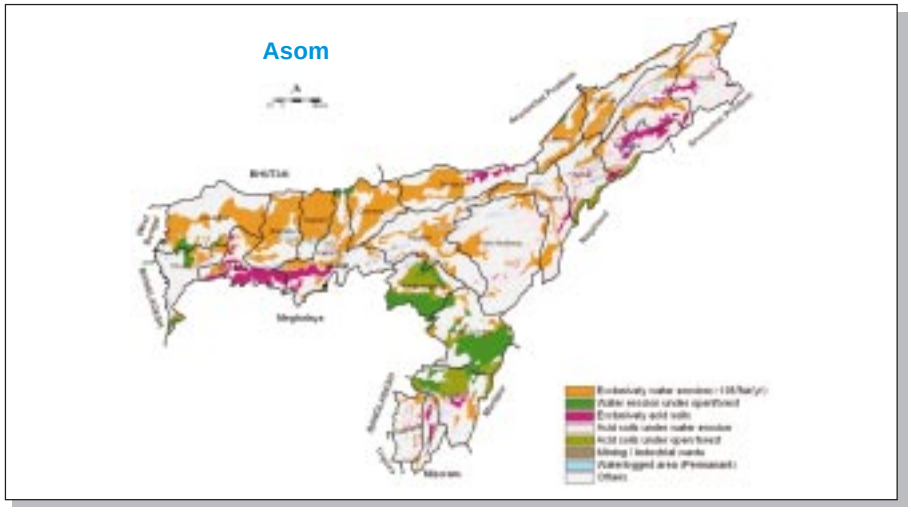

Fig. 12. Degraded and wastelands of Asom
Source: NBSS&LUP

Table 13. Degraded and wastelands statistics of Asom (Area in '000 ha)

Districts (21)	Degraded and wastelands classes*								Others**	Total
	1	2	3	4	5	18	19	Total of classes		
Barpeta	165	0	1	1	0	0	18	185	131	316
Cachar	26	50	16	65	92	0	7	256	129	385
Darrang	200	8	0	18	0	0	4	230	110	340
Dhemaji	122	0	0	0	0	0	6	128	188	316
Dhubri	40	34	4	1	4	0	9	92	185	277
Dibrugarh	63	0	37	131	0	0	19	250	95	345
Goalpara	33	0	84	11	0	0	1	129	60	189
Golaghat	91	0	13	139	2	0	8	230	99	352
Hailakandi	8	0	20	36	0	0	5	69	66	135
Jorhat	36	0	20	87	33	0	18	194	96	290
Kamrup	105	6	62	77	8	0	20	278	162	440
Karbi Anglong	113	116	6	288	69	0	19	611	441	1052
Karimganj	19	0	6	59	0	0	3	87	95	182
Kokarjhar	203	21	1	0	0	0	10	235	321	556
Lakhimpur	118	5	0	0	0	0	2	125	97	222
Nagaon	130	4	3	41	0	0	25	203	340	543
Nalbari	170	1	0	0	0	0	11	182	37	219
North Cachar	29	192	0	13	42	0	1	277	216	493
Sibsagar	25	0	70	120	15	0	18	248	31	279
Sonitpur	182	0	41	28	0	0	1	252	274	526
Tinsukia	51	0	27	204	0	0	5	287	100	387
Total	1,929	437	411	1,319	265	0	210	4,571	3,273	7,844

Notes: Classes*: **1** Exclusively water erosion (>10 tonnes/ha/yr); **2** Water erosion under open forest; **3** Exclusively acid soils; **4** Acid soils under water erosion; **5** Acid soils under open forest; **18** Mining/Industrial waste; **19** Waterlogged area (Permanent)
Others**: Normal agricultural lands, water-bodies, rivers, lakes and habitats etc. (based on the limited reconnaissance survey)
Source: NBSS&LUP

Arecanut is very prominent backyard crop. Sericulture is also practised in the state. The famous silks *eri* and *muga* are produced in this state. Kamrup, Goalpara and Barpeta districts grow jute-plant.

Degraded and Wastelands

Water erosion, soil acidity and waterlogging are the major land degradational problems in the state. Total degraded wastelands account for 4,571 thousand ha which is about 58% of the TGA. Water erosion affects 1,929 thousand ha (about 24% of TGA) of agricultural land and 437 thousand ha (about 5.5% of TGA) of open-forest area; thus affecting 29.5% of the total area of the state (Fig. 12; Table 13).

Soil acidity (affecting 25% of TGA) accounts for 1,995 thousand ha. Out of which, 1,319 thousand ha are also affected by water erosion. Karbi Anglong district has highest area (363 thousand ha) under acid soils, followed by Tinsukia (231 thousand ha) and Sibsagar (205 thousand ha).

Waterlogged area covers about 210 thousand ha (about 2.6% of the TGA). Karbi Anglong district has highest total degraded area (611 thousand ha), followed by Tinsukia (287 thousand ha), Kamrup (278 thousand ha), North Cachar (277 thousand ha), Cachar (256 thousand ha), Dibrugarh (250 thousand ha) and Sonitpur (252 thousand ha).

Manipur

Location

It lies between 93°03′ to 94°78′ E longitudes and 23°83′ to 25°68′ N latitudes, and covers 2.23 M ha (22,327 km^2). The state is surrounded in the north by hilly terrain of Nagaland, in the west by Asom and in the south by Mizoram. And Myanmar borders the state in the east.

Physiography

Manipur has a hilly terrain with its distinct geographic entity. The hilly terrain surrounds a central valley, elongating and tapering towards south, dotted by isolated hillocks. The hill ranges are aligned in a series of north-south parallel ridges. The eastern aspects of the hilly terrain are at the relatively higher elevation than those of the western aspects.

The western range has elevation of 800–1,100 m above msl and the eastern aspect has an elevation of 1,800–2,500 m above msl. The central valley is elongated in shape and tapers towards south; the valleys are interrupted by isolated hillocks. Physiographically, the state comes under Purvanchal hill region.

Geology

Rock formations in the state are of the Cretaceous limestone, the Disang with serpentinites (Lower and Middle Eocene–upper Cretaceous), the Barails (Upper Eocene and Oligocene), and the Surmas and the Tipams (Miocene) groups. The eastern part of the state abounds in narrow belts of fossiliferous cretaceous limestone and the formation of the Disang group intruded by serpentinites. Disang formations comprise grey-sandstone-grit, conglomerate limestone sequences intruded by serpentinites; containing minor amounts of enstatite, chromite, amphibole and magnetites.

Barail group, which is mainly arenaceous, occupies western and central part of Manipur, is distinguished from the younger Surma group by abundance of carbonaceous materials. The Surma and Tipam groups occur in the western margin of the state and are represented by argillaceous and arenaceous sequences, respectively, and are separated by a major anticline form of the

Cretaceous limestone in between synclinoria. The synclines form ridges and the anticlines form valleys (GSI, 1974).

Climate

The hilly terrain of the state is characterized by heavy precipitation, almost throughout the year, excepting seasonal distribution of rains in the central plains. Temperature variations are conspicuous in the hilly terrain. The eastern aspect of the hill ranges including central plain is relatively cooler than western counterpart. The region experiences humid climate with seasonal water deficiency. The climate of the eastern aspect is characterized by warm summers and cold winters with mean annual temperature of about 20°C. The summer temperature is around 29°C that drops to 0–12°C in the winter season. Mean annual precipitation varies from 1,200 to 1,350 mm, effectively meeting bulk of potential evapo-transpiration demand. However, seasonal water deficit occurs in January and February.

Western part experiences hot summers and cold winters. The mean annual temperature exceeds 22°C, and summer temperature ranges from 35 to 40°C. The mean annual precipitation varies from 2,000 to 2,650 mm.

Natural Vegetation

It consists of a large variety of plants, ranging from short and tall grasses, bamboos and trees of various species. The hilly terrain is occupied by medium to thick tropical deciduous forests, and ground is covered with thick undergrowth of bushes, shrubs, tall grasses and other types of mixed vegetation. Bamboo forests are common in the state with luxuriant growth in the lower and gentle hill slopes.

The flora in this region includes a variety of orchids, pines, oaks, teak, cane, etc. Among trees the most common species are: *amlokhi* (*Phyllanthus emblica*), *bokul* (*Mimosops elengi*), *chingsu* (*Tectona grandis*), *kadam* (*Anthocephalus cadamba*), silver oak (*Grevillea robusta*), mango (*Mangifera indica*), *neem* (*Azadrachta indica*), *champre* (*Citrus medica*), *chandan* (*Santalum album*), *chu* (*Saccharum officinarum*), *komola* (*Citrus aurantium*) and *lagihidak* (*Datura fastuosa*).

Soils

They belong to 4 orders, 8 suborders, 13 great groups, 22 subgroups and 29 families. Inceptisols dominate, covering 38.4% of the area, followed by Ultisols (36.4%), Entisols (23.1%) and Alfisols (0.2%). Marshy land and lake constitute about 2% of the area (Sen *et al.*, 1997). Soil subgroups are Typic Hapludalfs, Typic Udorthents, Typic Haplaquepts, Typic Dystrochrepts and Typic Haplohumults.

Land Use

Nearly 70% of the total geographical area of the state is under forests. Agriculture is the mainstay of the state's economy, and more than 75% of the people are engaged in agriculture. Agriculture is primarily of primitive nature in major part of the state. The area under cultivation is little more than 9% of the TGA of the state. '*Jhum*' cultivation is fairly common and is practised on slopes in the vicinity of the habitation. The gently sloping valley lands are bunded and terraced for intensive and permanent cultivations. The hilly regions are predominantly under horticultural crops like banana, pineapple, orange, guava, pear and plum. Paddy and maize are the most important cereal crops grown in the valley and non-cereals crops include pulses, chillies, cabbage, other vegetables, sweet-potato and ginger. On the hills, horticulture, tea and rubber plantations and agroforestry (silvi-horticulture, silvi-pastoral and agro-silvi-pastoral) are practised. Improved varieties of paddy and other cereals in the valley, and oilseeds and vegetables in the narrow inter-hill valleys are being cultivated by the farmers.

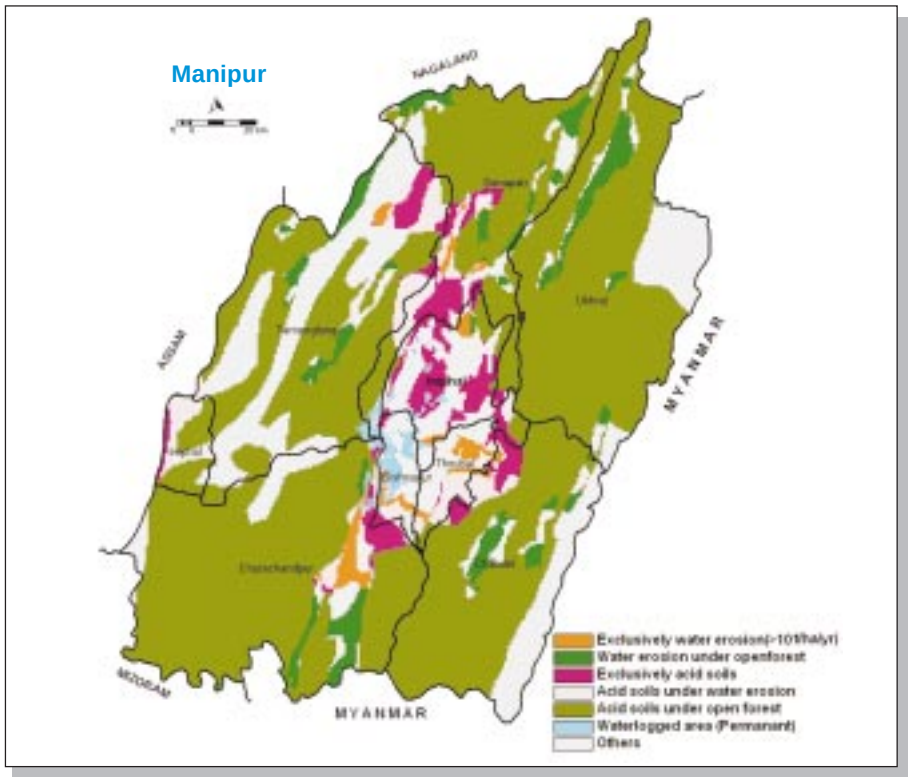

Fig. 13. Degraded and wastelands of Manipur
Source: NBSS&LUP

Table 14. Degraded and wastelands statistics of Manipur (Area in '000 ha)

Districts (8)	Degraded and wastelands classes*							Others**	Total
	1	2	3	4	5	19	Total of classes		
Bishnupur	5	0	4	7	1	12	29	21	50
Chandel	2	17	14	10	219	0	262	70	332
Churachandpur	11	22	14	6	358	2	413	42	455
Imphal	3	1	35	12	27	3	81	45	126
Senapati	4	24	30	15	216	3	292	36	328
Tamenglong	3	21	16	23	220	1	284	155	439
Thoubal	8	0	2	13	2	0	25	26	51
Ukhrul	0	29	0	0	353	0	382	69	451
Total	36	114	115	86	1,396	21	1,768	464	2,232

Notes: Classes*: **1** Exclusively water erosion (>10 tonnes/ha/yr); **2** Water erosion under open forest; **3** Exclusively acid soils; **4** Acid soils under water erosion; **5** Acid soils under open forest; **19** Waterlogged area (Permanent) Others**: Normal agricultural lands, water-bodies, rivers, lakes and habitats etc. (based on the limited reconnaisance survey)
Source: NBSS&LUP

Degraded and Wastelands

Manipur has 1,768 thousand ha degraded and wastelands, which is very high, around 79% of TGA of the state. Soil acidity and soil loss due to water erosion remain the major degradational processes. About 72% of the state is affected by soil acidity (1,597 thousand ha) and 6.7% is affected by water erosion, accounting for 150 thousand ha (Fig. 13; Table 14).

Among districts, Churachandpur has highest area under water erosion (33 thousand ha), followed by Ukhrul (29 thousand ha), Senapati (28 thousand ha) and Tamenglong (24 thousand ha). Total degraded and wastelands area also follows the same order of districts.

Meghalaya

Location

The state lies between 25°00′ to 26°10′ N latitudes and 89°45′ to 92°47′ E longitudes. It covers about 2.24 M ha (22,429 km^2). The state is bounded by Asom in the north, east and west side, and it shares an international boundary in the south and a part of the west with Bangladesh.

Physiography

The state can be broadly divided into three zones: the central plateau region, sub-montane region and a border region stretching southward abruptly; from the central plateau to the plains in the Bangladesh.

The central plateau region has elevation of 900–2,000 m above msl. The sub-montane region in continuation with the central plateau is below 900 m. The state represents part of an ancient plateau of Precambrian Indian peninsular shield, lifted to the present height of 600–1,800 m above msl. The plateau region stands as watershed between Surma valley of Bangladesh in the south and Brahmaputra valley in the north.

Geology

The state is occupied by Archaean gneisses complex with acidic and basic intrusions, Shillong group of rocks, Lower Gondwana rocks, Sylhet traps and Cretaceous Tertiary sediments.

Climate

It is per-humid with small seasonal water deficiency. The average rainfall ranges between 2,000 and 4,000 mm. The mean summer temperature rises as high as 26°C and mean winter temperature falls down to 9°C. At times it drops below freezing point. The mean annual soil temperature at higher elevations is less than 22°C but it is higher than 15°C; at lower elevations, it exceeds 22°C.

Natural Vegetation

The state is rich in flora from open scrub (grass) to pine forest in the central plateau region; the remaining area is covered mostly by tropical moist deciduous to evergreen forests. The most important species are *Bambusa polymorpha, Bambusa tulda, Dendrocalamus* spp., *Musa* spp. The deciduous forest species are *sal* (*Shorea robusta*) and teak (*Tectona grandis*).

Soils

Soils of the state belong to 4 orders, 8 subgroups, 14 great groups and 25 subgroups. Inceptisols occupy 46%, Ultisols 40%, Entisols 11% and Alfisols 4% of the total geographical area of the state.

Soils classified at subgroup level are Ustic Hapludalfs, Typic Udifluvents, Aquic Udifluvent, Typic Humaquepts, Cumilic Humaquepts, Typic Haplaquepts, Aeric Haplaquepts and Humic Haplaquepts (Singh *et al.,* 1999).

Land Use

About 85% of the population of the state is dependent on agriculture. And about 9% of the total geographical area is under cultivation, out of which only 26% is irrigated.

The principal crops grown are: paddy, wheat, maize, jute, mesta, cotton, tapioca, sweet-potato, mustard, chillies, turmeric, soybean, castor, chickpea and

pigeonpea. Main horticultural crops are: citrus fruits (predominantly orange), pineapple (both of queen and kew varieties), banana, litchi, guava, mango, jackfruit, pear, cashewnut, plum and peach. Tea and coffee plantations are also found at the government farms.

Degraded and Wastelands

In Meghalaya, degraded and wastelands account for 1,732 thousand ha, mostly contributed by soil acidity (1,023 thousand ha) and water erosion (706 thousand ha), amounting to 46% and 31% of TGA of the state. East Khasi hills

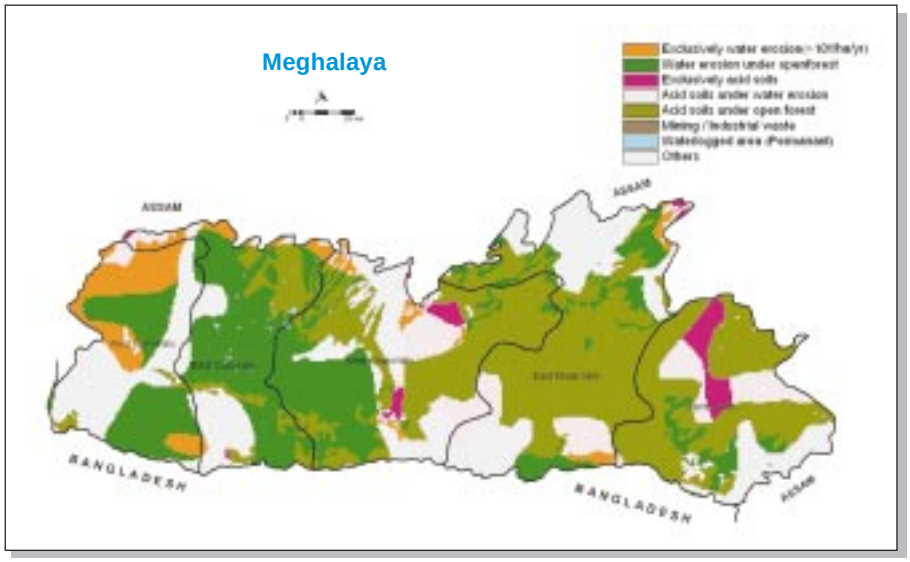

Fig. 14. Degraded and wastelands of Meghalaya
Source: NBSS&LUP

Table 15. Degraded and wastelands statistics of Meghalaya (Area in '000 ha)

Districts (5)	Degraded and wastelands classes*								Others**	Total
	1	2	3	4	5	18	19	Total of classes		
East Garo hills	23	229	2	11	76	0	2	343	89	432
East Khasi hills	11	69	2	52	294	0	1	429	149	578
Jaintia hills	0	30	34	51	221	0	0	336	59	395
West Garo hills	82	130	0	10	9	0	0	231	128	359
West Khasi hills	11	121	14	51	196	0	0	393	86	479
Total	127	579	52	175	796	0	3	1,732	511	2,243

Notes: Classes*: 1 Exclusively water erosion (>10 tonnes/ha/yr); 2 Water erosion under open forest; 3 Exclusively acid soils; 4 Acid soils under water erosion; 5 Acid soils under open forest; 18 Mining/industrial waste; 19 Waterlogged area (Permanent)
Others**: Normal agricultural lands, water-bodies, rivers, lakes and habitats etc. (based on the limited reconnaisance survey)
Source: NBSS&LUP

has about 348 thousand ha under acid soils, followed by Jaintia hills (306 thousand ha) and West Khasi hills (261 thousand ha). Waterlogged and marshy lands account for 3 thousand ha (Fig. 14; Table 15).

Mizoram

Location

The state is located between 21°33′ to 24°20′ N latitudes and 92°06′ to 93°20′ E longitudes occupying an area of 2.10 M ha (21,081 km^2), and it is flanked by Tripura, Chittagong hill tracts and Bangladesh in the west, Cachar (Asom) in the north, Manipur in the north-east, and Chin hill and Arkan hill tracts (Myanmar) in the east and south, respectively.

Physiography

The terrain of the state is young and immature. It shows prominent relief features with steep slopes, and is still undergoing denudation due to various exogenic and endogenic processes. Most dominant process in the evolution of these forms is the fluvial activity that is operating from the upper Tertiary onwards, till today. In the western part of the state, the valleys are wider with low relief. And in the western half, settlements cling to the valley flats while in the eastern half, they follow the crests. As such, physiographically, the Mizo hills can be divided into Mizo hills west and Mizo hills east. Both east and west parts can be divided into three sub-zones depending on the intensity of the slopes, steep hill slopes; moderate hills slopes, and gently sloping uplands.

Mizo hills elevation is confined between 150 m and 900 m, though peaks of over 1,500 m elevations also occur. The most typical and undisturbed pattern of parallel drainage can be noticed on the Mizo hills. Rivers have cut hill ranges at suitable points, almost at the right angles, resulting into barbed patterns.

Geology

Geologically Mizoram forms a part of Tripura. Mizoram geosynclinals' depositional basin extends north into the Surma valley. Hill regions forming anticlineal crests expose relatively compact and resistant older rock types while valleys are composed of younger, softer formations in synclinal troughs. Geomorphologically the region may be considered immature. Mizo hills constitute a part of eugosynclinal mobile belt of the Asom-Arakan geosynclines, comprising geosynclinal molasse-type sediments of Neogene age. The sediments consist dominantly of a repetitive succession of fine-grained arenaceous and argillaceous clastics. The sedimentary succession at Mizoram is of the repetitive

sequence proportions of alterating shale, silt stone, mudstone and fine-grained sandstone.

Climate

The state has a pleasant climate, humid tropical with mean annual humidity of 86.45%; generally cool in summer and not very cold in winter. There is no snowfall, but frost is experienced in the eastern parts. The mean winter temperature varies between 21° and 27°C. The mean annual temperature is 20°C, and the difference between mean summer and mean winter temperature exceeds 5°C. The area lies under the direct influence of monsoon and average rainfall in the area is 2,170 mm per annum.

Natural Vegetation

Mizoram has a great natural beauty with endless variety of trees, plants, grasses and bushes, and bamboos grow abundantly everywhere.

Among the most common species on the lower elevations, mention can be made of *naga bhe* (*Schima wallichii*) which, though seen in plains, is common on the hills, where it grows to a larger size. *Photiki* and *photkola* (different species of *Melastoma*) grow in deep ravines and assume form of small trees (3 to 4 m high). Bamboo jungle is extensive everywhere, but it exhibits a better growth in low-lying tracts and ravines. Apart from these, *Mesua ferrea, Careya arborea, Ficus elastica,* are found commonly under the tropical evergreen group. Trees growing on hill slopes above 1,800 m are oak, chestnut, magnolia, cherry, maple, laurel, fig and moly and comprise temperate evergreen type of forest. The forest above 2,100 m is cool temperate, and is covered by *Pyrus, Sorbus, Acer* and *Magnolia cambellii.*

Soils

In Mizoram, though soils have been developed on shales and sandstones, but ecosystem significantly influences process of soil formation. Due to high precipitation and favourable condition of temperature and vegetation, weathering is intense.

Soils of Mizoram mainly belong to 4 orders, 7 suborders, 11 great groups and 13 subgroups. Inceptisols are the dominant soils, followed by Ultisols, Entisols and Alfisols (Maji *et al.,* 2001).

Land Use

Of the total geographical area, forest covers 18,775 km^2, and total cropped area including horticulture is 98 thousand ha. Agriculture is the main occupation of the people, and about 5% of the total area is under cultivation. *Jhuming* is the

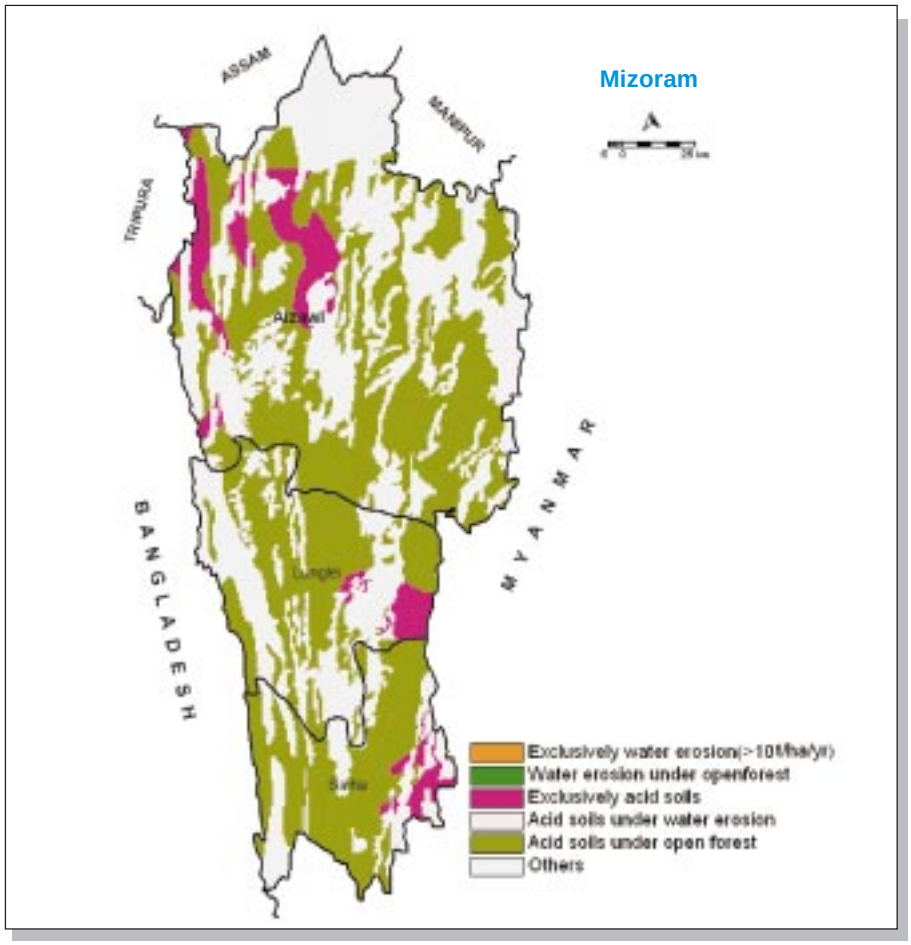

Fig. 15. Degraded and wastelands of Mizoram
Source: NBSS&LUP

Table 16. Degraded and wastelands statistics of Mizoram (Area in '000 ha)

Districts (3)	Degraded and wastelands classes*						Others**	Total
	1	2	3	4	5	Total of classes		
Aizwal	0	0	100	0	548	648	611	1,259
Lunglei	0	0	25	0	224	249	205	454
Saiha	0	0	25	0	241	266	129	395
Total	0	0	150	0	1,013	1,163	945	2,108

Notes: Classes*: **1** Exclusively water erosion (>10 tonnes/ha/yr); **2** Water erosion under open forest; **3** Exclusively acid soils; **4** Acid soils under water erosion; **5** Acid soils under open forest
Others**: Normal agricultural lands, water-bodies, rivers, lakes and habitats etc. (based on the limited reconnaisance survey)
Source: NBSS&LUP

usual practice, 80% of the total population is practising *jhum* cultivation.

Various crops are grown in mixed cropping. Paddy and maize are principal crops, and horticultural crops and spices like ginger are grown abundantly.

Degraded and Wastelands

Soil acidity remains a major degrading process, affecting 1,163 thousand ha (55% of TGA). Among the districts, Aizwal is worst affected by degradation, followed by Saiha and Lunglei. In the state, degraded and wastelands with particular reference to water erosion have been calculated on the basis of the extrapolation. It is expected to be much higher owing to climate and terrain conditions (Fig. 15; Table 16).

Nagaland

Location

Nagaland is located between 25°06′ to 27°04′ N latitudes and 93°21′ to 95°15′ E longitudes. It covers 1.6 M ha (16,579 km^2). It is bounded by Asom in the north, Myanmar in the west, Arunachal Pradesh in the east and Manipur in the south.

Physiography

State is represented by hilly terrain comprising closely spaced elevated ridges with alternate "V" shaped intermountain valleys. Topographically landscape can be grouped into foothills with undulating to rolling topography of less than 100 m altitude, facing Asom plains on the northern side, lower ranges and mid-ranges, with varying degree of slopes with an elevation of 1,000 m and above, and high hills and mountainous regions.

The state has many narrow strips of hilly ridges running north-east to south-east. The Borail range enters the state at the south-west corner and runs in a north-easterly direction, almost up to Kohima. Near Kohima, the Borail range merges with the mountain ranges, which extend to Manipur and the main range assumes a much more northerly trend. This range is considerably higher than the Borail, with peaks like Saramati (3,826 m) and Mataungse Kien (3,420 m) at its extreme east. Between Mon and Kohima, there are several very high peaks, including Japro in the north of Kohima. The main ridge declines in height at the far north at Mokochung district, and the Japukong range attains an average elevation of 750 m.

Geology

The state is located in the northern extension of the Arkan Yoma ranges, which are of Tertiary Cretaceous age and belong to a fairly young mobile belt of

the earth. The rock sequence is of the geosynclinal fecies, represented by the Disang group (Lower and Middle Eocene, Upper Cretaceous), the Borail group (Upper Eocene and Oligocene), the Surma group and the Tipam group (Miocene), the Namsang beds (Mio-Pliocene) and the Dibing group (Pliocene-Pleistocene).

The Disang group consists of monotonous sequence of dark grey splintery shales with thin beds of sandstone. In parts of the Naga hills, the Disang shales are splintery and sometimes slaty with numerous thin ramifying quartz veins.

The Borail range enters the state at the south-west corner and runs in the north-eastern direction almost up to Kohima, and thereon merges with the mountain range.

The Surma group which is essentially an alternation of shales and sandstone with more thin conglomerate, overlies the Borails. The Tipam group consists of ferrugineous sandstone of huge thickness of clay layers in the Naga hills. The Dibing group represented by pebble beds, thin clays and sand rests over the Namsang beds.

Climate

The climate of the state is controlled to a large extent by its terrain features. It is hot to warm sub-tropical in areas with elevations of 1,000–1,200 m above msl. It is warm sub-temperate in areas with elevations of 1,200 m and above. Rainfall is heavy, with an average annual rainfall of 1,940 mm in Kohima. And the rainy season is generally from April to September/October.

Temperature varies from 0°C in winter to 40°C in summer and average annual air temperature ranges from 18° to 20°C and 23° to 25°C, based on the elevation.

Natural Vegetation

The state is rich in flora and ground is covered with thick undergrowth of bushes, shrubs and tall grasses. The forest comprises sub-tropical to evergreen species and varies from open scrub to thick forest. And bamboo forests are common on lower and middle slopes of the hills. The dominant species are: *amlokhi* (*Phyllanthus emblica*), bamboo (*Bambusa polymorpha*), *bola* (*Morus laevigata*), *chingsu* (*Tectona grandis*), *huagoni* (*Castanopsis* spp.), hollock (*Terminalia myriocarpa*), silver oak (*Grevillea robusta*), *siloni* (*Schima wallichii*), *tejpat* (*Cinnamomum tamala*), *komola* (*Citrus aurantium*), pineapple (*Ananas comosus*), banana (*Musa parodisiaca*) etc.

Soils

Soils of the state belong to 4 orders, 7 suborders, 10 great groups and 14 subgroups. Alfisols cover 2.9%, Entisols 7.3%, Inceptisols 66% and Ultisols cover

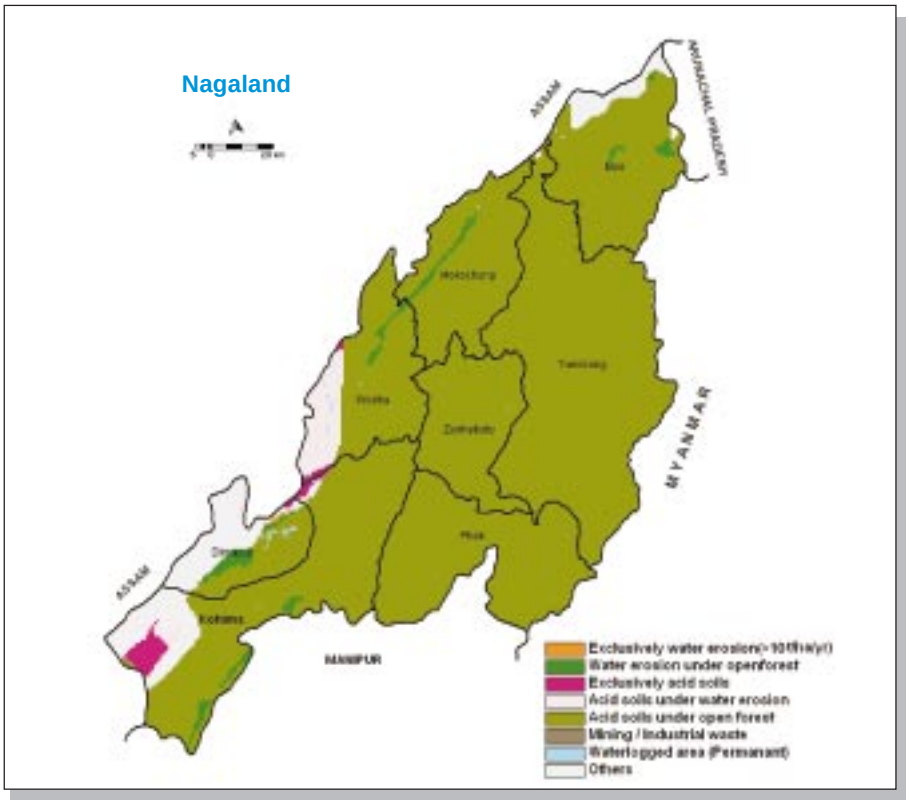

Fig. 16. Degraded and wastelands of Nagaland
Source: NBSS&LUP

Table 17. Degraded and wastelands statistics of Nagaland (Area in '000 ha)

Districts (8)	Degraded and wastelands classes*								Others**	Total
	1	2	3	4	5	18	19	Total of classes		
Dimapur	1	8	1	5	38	0	1	54	41	95
Kohima	0	8	13	4	241	0	1	267	45	312
Mokochung	0	6	0	0	155	0	0	161	0	161
Mon	0	4	0	0	153	0	0	157	22	179
Phek	0	0	0	0	202	0	0	202	0	202
Tuensang	0	0	0	0	421	0	0	421	0	421
Wokha	0	4	3	36	119	0	1	163	0	163
Zunheboto	0	0	0	0	125	0	0	125	0	125
Total	1	30	17	45	1,454	0	3	1,550	108	1,658

Notes: Classes*: **1** Exclusively water erosion (>10 tonnes/ha/yr); **2** Water erosion under open forest; **3** Exclusively acid soils; **4** Acid soils under water erosion; **5** Acid soils under open forest; **18** Mining/Industrial waste; **19** Waterlogged area (Permanent)
Others**: Normal agricultural lands, water-bodies, rivers, lakes and habitats etc. (based on the limited reconnaisance survey)
Source: NBSS&LUP

24% of the TGA of the state (Maji *et al.,* 2000). Seventy-two soil families have been identified and mapped into 36 soil units.

Land Use

Of the total geographical area of the state, about 11% is under cultivation, and irrigated area comprises 3% of the cultivated area. People of the state have still adopted primitive practice of shifting (*jhuming*) cultivation extensively on the hill slopes; in 99 thousand ha. In the *jhum* land and on the terraced slopes, mixed cropping is practised with paddy, maize, millets, chillies, sweet-potato, tapioca, mustard, wheat. In wetlands, crop rotations, like paddy-paddy and paddy-wheat are practised.

Degraded and Wastelands

These lands occupy 1,550 thousand ha, accounting for 93% of TGA of the state. Like Arunachal Pradesh and Mizoram, Nagaland is predominantly affected by soil acidity. Acidity affects 1,516 thousand ha (91% of TGA) under different associated degraded lands. Water erosion affects 31 thousand ha (1.8% of TGA). Tuensang has remained highly degraded (421 thousand ha), followed by Kohima (267 thousand ha), Phek (202 thousand ha) and Mokochung (163 thousand ha). Soil erosion is highest in Kohima, followed by Dimapur, Mokochung, Mon and Wokha (Fig. 16; Table 17).

Sikkim

Location

It is located between 27°04′ to 28°07′ N latitudes and 88°01′ to 88°55′ E longitudes and is spread over 7.09 M ha (7,096 km^2). The state is bounded in the north by the vast stretches of the Tibetan plateau, in the west by Nepal, in the east by Bhutan and Chumbi valley of Tibet. Darjeeling district of West Bengal stretches along its southern boundary.

Physiography

The area of Sikkim can be divided into nine unequal geomorphic entities: summits and ridges, escarpments, very steep slopes, steep slopes, moderately steep slopes, narrow valleys, cliffs and precipitous slopes, zones of glacial drifts/moraines/boulders and perpetual snow. The elevation of the state ranges between 300 m at southern foothills and 5,500 m above msl in its north and north-west sides.

The general run of the main ridges is north-south with subsidiary interlacing spurs from each ridge in a roughly east-west direction. Singalela and Chola ranges arising from the great Himalayas determine its boundary in the east

and the west. Another north-south chain runs through its central portion, separating Rangit from Tista valley. All these ridges are lofty indeed with an average elevation exceeding 800 m above msl.

Geology

Sikkim is the part of the lesser Himalayan terrain of eastern sector. Tectono-stratigraphically, it has been classified under four tectonic belts:foothill belt, inner belt, axial belt and transaxial belt. The state is predominantly covered by unfossiliferous metamorphic and crystalline rocks grouped in the inner and axial tectonic belts.

Climate

Its climate generally varies from sub-tropical to alpine depending upon the elevation of the place. Mean annual rainfall varies from 2,000 mm to 5,000 mm with intensity ranging from drizzle to torrential rains.

Rainfall is heavy and well-distributed from May to September; July is the wettest month in most of the places. Rainfall is moderate from April to October. It is generally low during November to February. Rainfall pattern is essentially monsoonal. Average annual temperature is 27°C. The temperature is very cool in north as compared to the south, and reaches 0°C in winter.

Natural Vegetation

Its natural vegetation consists of evergreen trees, grasses and bushes, which extends to 4,000 m above msl, and above 5,000 m msl hardly any vegetation is found.

Distrbution pattern of natural vegetation in the state may be divided into 5 mixed forest zones. Lower hill forests (<900 m) consist of *sal* forests and are generally confined to the Tista and Rangit valleys. *Pakasaj, lampatey, simul, chilawne, lali* (*Dysoxylum gobarum*) are some of the important associate species. Middle hill forests (900–1,800 m) are dominated by trees like *murse katus* and *dalne katus* besides walnut. Upper hill forests (1,800–2,450 m) consist of *mawa*, *rani* and *champa (Michelia champaca). Rhododendron* and oak forests are found at elevations ranging from 2,450 to 3,350 m. The main trees are *Quercus lamellosa, Q. pacheyphylla,* mostly mixed with *Acer campbellii, Rhododendron.* Conifer forests (2,450–3,350 m) are found in the low rainfall zone of the north district. Alpine pastures comprise dwarf junifers and *Rhododendron* and exclusive grassy meadow with *Deschampsia caespitosa* and *Salix* sp.

Land Use

Sikkim has a total area of about 7,096 km^2; of which 11% is under agriculture. Forest and barren land covers 35% and 24% of the TGA.

Agriculture in Sikkim is well established compared to other hill states in the north-eastern Himalayan hill region. Agricultural land is at elevation of 300 to 3,000 m, but most of the cultivated land is below 1,800 m. Agriculture on 30–

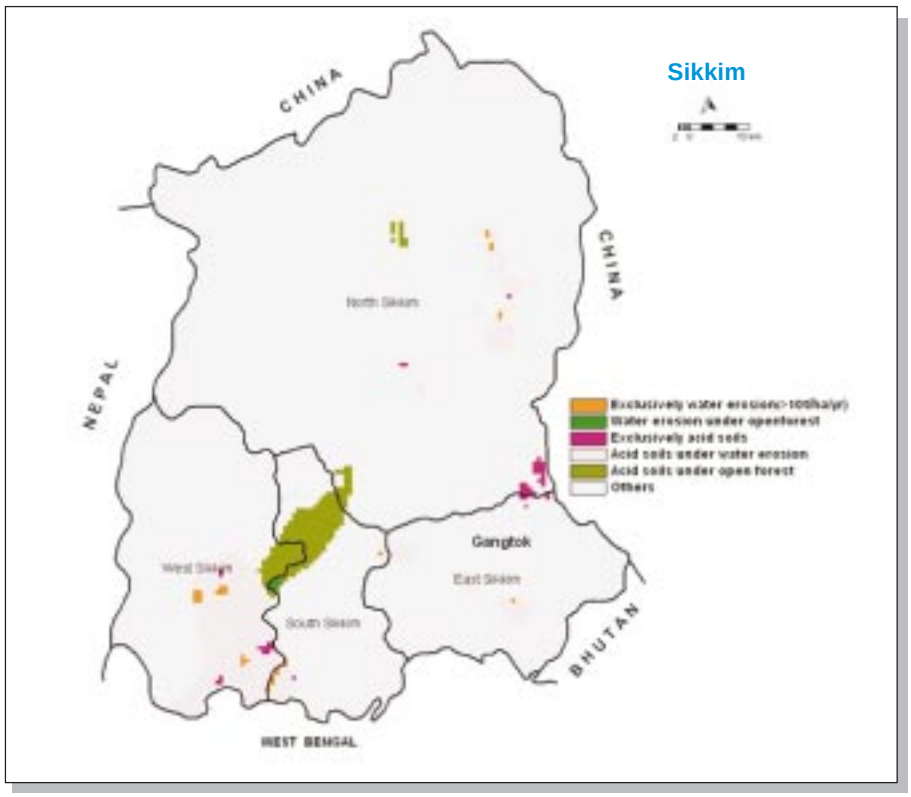

Fig. 17. Degraded and wastelands of Sikkim
Source: NBSS&LUP

Table 18. Degraded and wastelands statistics of Sikkim (Area in '000 ha)

Districts (4)	Degraded and wastelands classes*						Others**	Total
	1	2	3	4	5	Total of classes		
East Sikkim	0	0	0	5	0	5	92	97
North Sikkim	0	0	1	7	2	10	411	421
South Sikkim	1	0	0	3	8	12	62	74
West Sikkim	1	0	1	28	3	33	85	118
Total	2	0	2	43	13	60	650	710

Notes: Classes*: **1** Exclusively water erosion (>10 tonnes/ha/yr); **2** Water erosion under open forest; **3** Exclusively acid soils; **4** Acid soils under water erosion; **5** Acid soils under open forest
Others**: Normal agricultural lands, water-bodies, rivers, lakes and habitats etc. (based on the limited reconnaisance survey)
Source: NBSS&LUP

50% slope is common but at altitudes above 1,500 m, land with >50% slope has also been brought under cultivation. Paddy is the common cereal. Maize, wheat and vegetables are also grown in the state. Sikkim is rich in orchids, and spices like cardamom is grown in a vast area of the state.

Soils

Soils of the state belong to Inceptisols (43% of TGA); Entisols (42%) and Mollisols (15%), and 7 suborders, 12 great groups and 26 subgroups. Haplumbrepts with 31% of TGA is the most predominant great group, followed by Udorthents (30%), Cryorthents (12%) and Hapludolls (12%). Among subgroups, most prominent ones are Typic Haplumbrepts (20%) and Cumulic Haplumbrepts (5%); Lithic Udorthents (19%) and Typic Udorthents (10%); Typic Hapludolls (5%) and Cumulic Hapludolls (2%) (Das *et al.,* 1996).

Degraded and Wastelands

Total degraded area in Sikkim is 60 thousand ha (9% of TGA); of which West Sikkim is highly degraded, followed by South Sikkim and North Sikkim (Fig. 17, Table 18).

Erosional hazard has affected about 2 thousand ha (0.28% of TGA of the state). South Sikkim is worst affected district, followed by West Sikkim and North Sikkim. Sikkim being hilly state practising terraced agriculture on an extensive scale could successfully control soil erosion.

Soil acidity, a major problem of Sikkim, accounts for 58 thousand ha (about 8% of the area of the state); West Sikkim has highest area (32 thousand ha), followed by South Sikkim (11 thousand ha), North Sikkim (10 thousand ha) and East Sikkim (5 thousand ha).

Tripura

Location

Tripura covers 1.04 M ha (10,486 km^2) and is situated between 22°57′ to 24°32′ N latitudes and 91°09′ to 92°20′ E longitudes. It is bounded by Bangladesh in the south, north-west and south-east, and Mizoram in the east and Asom in the north-east.

Physiography

The state has been divided into 10 physiographic units: steeply sloping and slightly dissected high relief, structural hills and ridges; moderately sloping with moderately dissected, medium relief parallel ridges; moderately sloping and highly dissected, low relief structural hills and ridges; moderate to gently

sloping and moderately dissected, flat-topped denuded hills; low-lying residual hills with valleys; gently sloping, undulating plains with low mounds and narrow valleys; moderately to gently sloping, Interhill valleys with uplands; moderately to gently sloping, interhill valleys with upland alluvial plains; flood plains; and rolling uplands.

Geology

The state is represented by sedimentary rocks, which range in age from Miocene to loosely consolidated sediments of the recent age. The rocks are sandstone, silt stone and shale grading into clay. These rock types are repeated as layers one above the other. Depending on their characters and presence of fossils, these sedimentary rock sequences are divided into Surma group (the oldest), Tipam group and Dupitila group (the youngest). From the nature of the grains and the texture imprinted on these rocks, it is inferred that originally sediments were deposited in the sea and later they converted into rocks. Quite a larger part of south Tripura district is occupied by the recent fluvial deposits. The sedimentary rocks are deformed and folded.

Climate

It varies from sub-tropical to alpine depending upon the elevation of the place. Mean annual rainfall varies from 2,000 mm to 5,000 mm with intensity ranging from a drizzle to torrential rains. The area experiences winter and summer showers to a limited extent. Humidity ranges from 100 to 42%. The monsoon generally starts by the end of May. The average mean annual temperature varies from 20.1° to 24.6°C and the mean winter temperature is 16°C and summer temperature is 28.2°C

Natural Vegetation

Forests cover mostly elevated flat lands, hillocks and high hills and are practically absent in the lowlands (*lungas*). The state is mainly occupied by *sal* (*Shorea robusta*). The principal deciduous trees like teak (*Tectona grandis*), *karai* (*Albizia procera*), *hargaja gamair* (*Gmelina arborea*) and wild *neem* (*Azadirachta indica*) are quite common. *Ban tulsi* (*Stereospermum* sp.) is found in abundance with *san* and *kas* grasses. Bamboo species found are *rupai* (*Dendrocalamus longispathus*), *parwa* (*Bambusa teres*), *pocha* (*Dendrocalamus hamiltonii*) and *dolu* (*Teinostachyum dullooa*). Sub-dominant natural vegetation is *chamal* (*Artocarpus chaplasha*), *khemta* (*Chukrasia tabularis*), *awal* (*Vitex peduncularis*), *semul* (*Bombax malabaricum*) and sangrass (*Imperata cylindrica*). *Muli* (*Melocana bambusoides*) and *mitinga* (*Bambusa tulda*) bamboos are grown in *jhumed* areas. In the alluvial tract, *kul*, palm, datepalm are quite common.

Mango, litchi, jackfruit, black berries also occupy a sizeable area. Besides, wild banana (*Musa* spp.) is also found in the hilly tracts of the region.

Soils

The soils of Tripura belong to 5 orders, 7 suborders, 9 great groups and 19 subgroups. The 5 orders are Inceptisols, Entisols, Ultisols, Alfisols and Histosols, occupying 80.6%, 8.1%, 6.6%, 4.5% and 0.2% of TGA. Generally, Inceptisols, Ultisols and Alfisols are observed in patches in hills and *tilla* lands. Entisols are observed in patches in the hills as well as in interhill basins. Paddy soils by and large are grouped into Inceptisols with aquic moisture regime and are taxonomically known as Aquepts (Bhattacharyya *et al.,* 1996).

Land Use

Out of the total geographical area of 1,049 thousand ha of the state, 58% is occupied by forests, followed by 26% as net sown area. The area sown more than once is 65%. The valley land locally known as '*lungas*' is well suited for common agricultural crops, while highlands locally called '*tillas*' are fit for plantation crops but are often used for shifting cultivation called *jhum*. Paddy alone occupies 58% of the total cropped area. The two important commercial crops grown are rubber (21,000 ha) and tea (5,780 ha). On the *tillas* and *lungas* cultivation of sugarcane, potato, groundnut, ginger and turmeric is gradually getting popular. Double cropping is practised in irrigated areas. A number of tropical and subtropical fruits, pineapple, jackfruit, orange, litchi, banana have been successfully grown on *tillas*. Introduction of cashewnut has been found promising.

Degraded and Wastelands

Total degraded and wastelands are estimated to be 785 thousand ha (74% of TGA). Agartala (224 thousand ha) is worst affected, followed by Kailashahar (199 thousand ha), Ambasa (194 thousand ha) and Radha-kishorepur (168 thousand ha).

Water erosion (in 7% of TGA) has been observed in 74 thousand ha; of which open forest area accounts for 48 thousand ha. Kailashahar (25 thousand ha) is worst affected, followed by Ambasa (21 thousand ha), Agartala (19 thousand ha) and Radha-kishorepur (9 thousand ha).

Acid soils cover 709 thousand ha (about 67% of TGA). Soil acidity is highly prevalent in Agartala (205 thousand ha), followed by Kailashahar (174 thousand ha), Ambasa (172 thousand ha) and Radha-kishorepur (158 thousand ha). Over 2 thousand ha is either marshy or waterlogged for most part of the year (Fig. 18; Table 19).

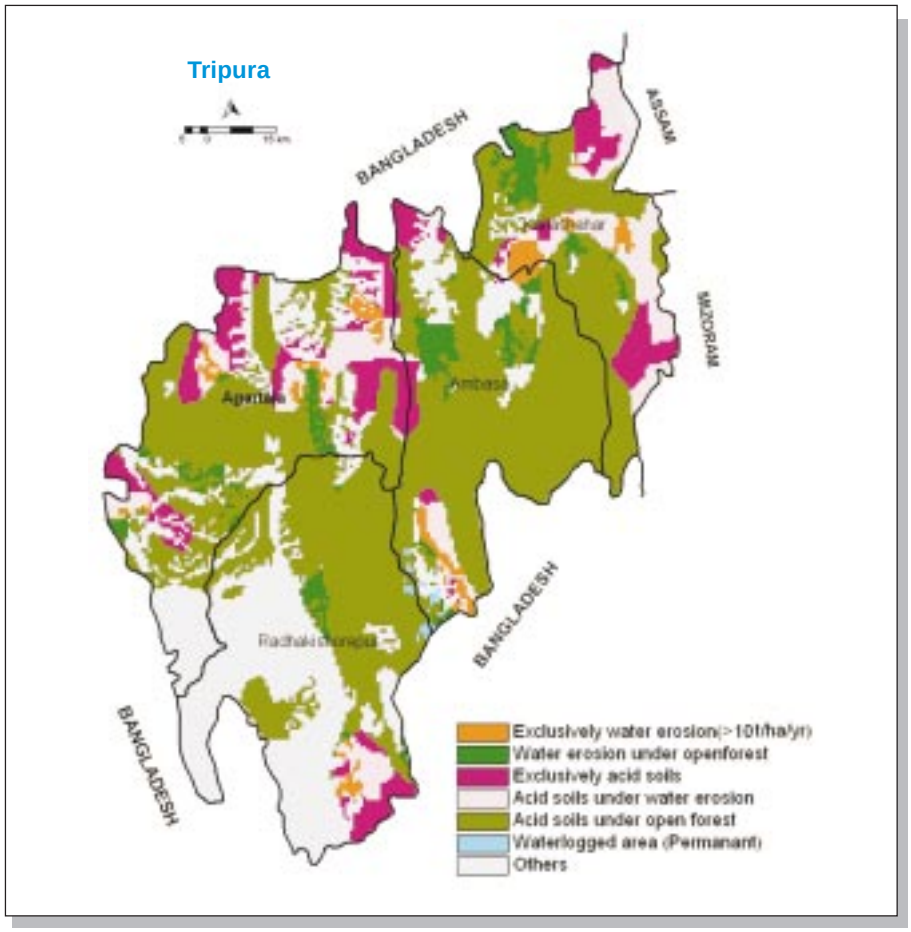

Fig. 18. Degraded and wastelands of Tripura
Source: NBSS&LUP

Table 19. Degraded and wastelands statistics of Tripura (Area in '000 ha)

Districts (4)	Degraded and wastelands classes*							Others**	Total
	1	2	3	4	5	19	Total of classes		
Agartala	8	11	50	25	130	0	224	77	301
Ambasa	6	15	10	6	156	1	194	29	223
Kailashahar	9	16	29	44	101	0	199	11	210
Radha-kishorepur	3	6	12	8	138	1	168	147	315
Total	26	48	101	83	525	2	785	264	1,049

Notes: Classes* **1** Exclusively water erosion (>10 tonnes/ha/yr); **2** Water erosion under open forest; **3** Exclusively acid soils; **4** Acid soils under water erosion; **5** Acid soils under open forest; **19** Waterlogged area (Permanent)
Others**: Normal agricultural lands, water-bodies, rivers, lakes and habitats etc. (based on the limited reconnaisance survey)
Source: NBSS&LUP

NORTHERN REGION

The northern region comprises Delhi, Haryana, Himachal Pradesh, Jammu and Kashmir, Punjab, Uttar Pradesh and Uttarakhand.

Delhi

Location

It is situated between 28°24′17″ to 28°53′00″N latitudes and 76°50′24″ to 77°20′37″E longitudes. It occupies 148 thousand ha (1,483 km^2), of which 47,000 ha falls under urban area. The state is surrounded by Uttar Pradesh in the east and Haryana in the north, west and south.

Physiography

Major physiographic units identified are: Flood plains, recent alluvial plains, Old alluvial plains, Aravalli hills, Pediment and Piedmonts. The Aravalli hills from Rajasthan enter Delhi on the southern border and extend into an elongated ridge of 5–6-km width along north to north-east and south to south-west. These are separated by flat lands and depressions filled with alluvial material.

Geology

Delhi state is a part of the Indo-Gangetic alluvium. The Aravallis are composed of quartzites and interbedded with micaceous schists that belong to Alwar formations of the Delhi system, and are of Precambrian age. They also include pegmatites and quartz vein representing acid igneous phase of post-Delhi age. The rocks include fine-grained to coarse-grained quartzite with variegated colours, gray, pink, brick-red and buff, and thus indicate evidences of surface weathering and disintegration into loose grains of quartz.

Climate

Its climate is semi-arid, and its summers and winters both are extreme with mean maximum and minimum temperatures of 40.5°C and 27.6°C in summer and 22.2°C and 7.5°C in winter. Dust storms are common during summer when day temperature ranges 40° to 50°C in May and June. Mean annual rainfall is 612 mm; 80% of which is received during monsoon months of July to September from south-west monsoon.

Natural Vegetation

The common trees are *babul (Acacia nilotica)*, *palas* (*Butea monosperma*), *shisham (Dalbergia sissoo)*, banyan *(Ficus bengalensis)*, *pipal (F. religiosa)*, *ber (Zizyphus jujuba)* and *neem (Azadirachta indica)*.

Forest area is limited to only 3%. Spatial distribution of forest is not uniform but is in patches in various parts of the state; maximum concentration being in the eastern part along with the river Yamuna and Aravalli ranges.

Soils

The soils belong to 2 orders, 4 suborders, 4 great groups, 6 subgroups, and 12 soil families. Inceptisols are found predominantly (81%), followed by Entisols (19%); representing 55% and 13% of the total geographical area of the state. Entisols have 3 suborders, of which Orthents constitute 55%. Inceptisols have only one suborder (Ochrepts) and one great group (Ustochrepts) (Mahapatra *et al.,* 2000).

Land Use

The land-use pattern of Delhi has changed dramatically during the last few decades. There has been a decline in agricultural land due to rapid urbanization and industrialization. In 1970–71, there were about 26,000 industrial units which

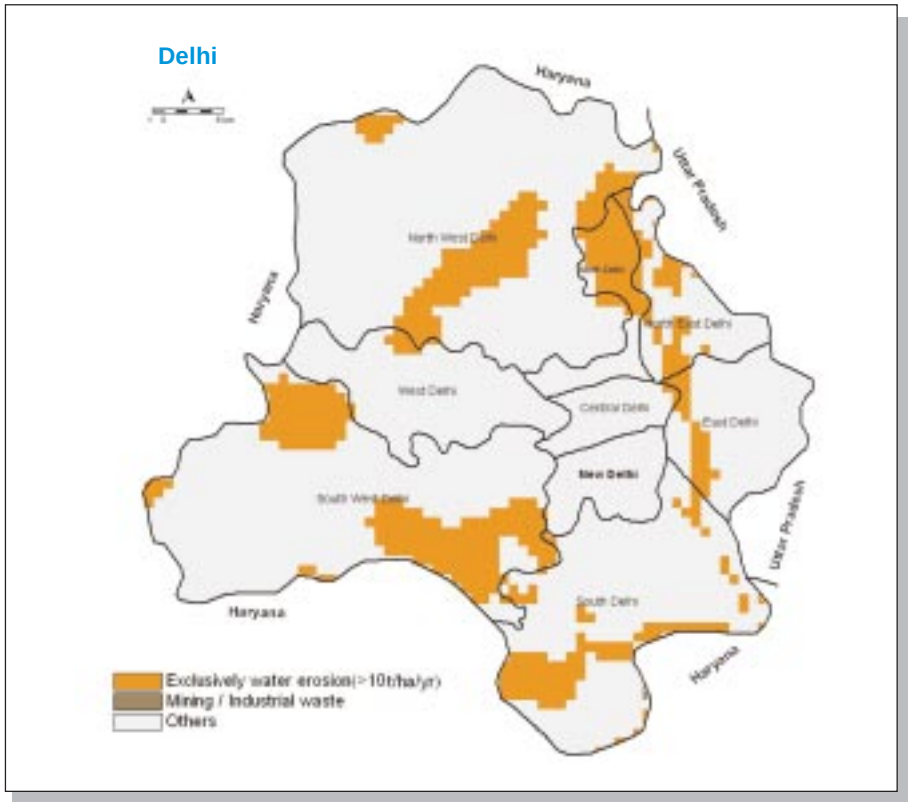

Fig. 19. Degraded and wastelands of Delhi
Source: NBSS&LUP

Table 20. Degraded and wastelands statistics of Delhi (Area in '000 ha)

Districts (9)	Degraded and wastelands class	Others*	Total
	Exclusively water erosion (>10 tonnes/ha/yr)		
Central Delhi	0	1	1
East Delhi	1	6	7
New Delhi	0	4	4
North Delhi	3	3	6
North East Delhi	2	4	6
North West Delhi	6	38	44
South Delhi	5	20	25
South West Delhi	11	31	42
West Delhi	0	13	13
Total	28	120	148

Note: Others*: Normal agricultural lands, water-bodies, rivers, lakes and habitats etc. (based on the limited reconnaisance survey)
Source: NBSS&LUP

increased to 68,000 in 1986–87 and further increased to 93,000 in 1993. In 1970–71, net sown area was 80,500 ha, which decreased to 58,000 ha in 1980–81, 48,000 ha in 1990–91 and further decreased to 46,000 in 1993–94. And there was 36,000 ha of potential land for multiple cropping in 1970–71, it decreased to 29,000 ha in 1980–81 and 27,800 ha in 1990–91 and to as low as 14,800 ha in 1993–94 showing that major portion (about 60%) of the most potential agricultural land has been used for non-agricultural purposes.

Major crops grown are wheat, *jowar*, paddy, *bajra* and barley. Out of the total cropped area of 60,857 ha in 1993–94, 51% was under wheat, followed by sorghum16%, millets 5%, paddy 1% and barley 0.3%, and rest of the area was under minor crops.

Degraded and Wastelands

North-western and southern parts of Delhi are found to have major problems of degraded and wastelands. About 19% of the TGA of Delhi is affected by water erosion. South-West Delhi is worst affected (11 thousand ha), followed by North-West Delhi (6 thousand ha), South Delhi (5 thousand ha) and North Delhi (3 thousand ha); a little area is affected by salinity also (Fig. 19, Table 20).

Haryana

Location

The state covers a total geographical area of 4.42 M ha (44,212 km^2), and lies between 27°39′ to 30°55′ N latitudes and 74°27′ to 77°36′ E longitudes. It is bordered by Delhi, Rajasthan, Punjab, Himachal Pradesh and Uttar Pradesh.

Physiography

The landscape of the state varies from hills in the northern region to almost level alluvial plains in the central parts and sand-dunes in the southern districts. Major part of the state forms a part of the Indo-Gangetic alluvial plains. The state has 4 main physiographic regions: Siwalik hills, Alluvial plains, Aravalli hills and Aeolian plains. These are further subdivided into Aeolian plains, Aeo-fluvial plains, Active alluvial plains, Recent alluvial plains, Old alluvial plains, Gently sloping Aravalli plains, Piedmont plains, steeply sloping Siwalik hills and Aravalli hills.

Geology

The geological formation ranges from Precambrian to recent times.

Aravalli system is the oldest formation in the south-western part of the state. It covers Bhiwani, Mahendragarh and Gurgaon and is composed of quartzites, quartzitic sandstone, mica schists, phyllites and crystalline limestone.

Siwalik system is located in the northern part of Ambala district and is composed of sedimentary rocks like sandstones, shales, clays and boulders. Indo-Gangetic Alluvial plains have been formed by deposition of alluvial sediments between Siwaliks and Aravallis. Wind-blown sand deposits are found in the form of sandy plains and sand-dunes over alluvial deposits in parts of Bhiwani, Hisar and Sirsa districts.

Climate

The state has three main climatic regions. The average annual rainfall in the hot arid region is 300–500 mm, in hot semi-arid region is 500–750 mm and in the hot sub-humid region is 750–1,050 mm, and air temperature of hot arid region is 27°C, hot semi-arid region is 26°C and hot sub-humid region is 24°C. The annual average rainfall of the state is 650 mm, varying from less than 300 mm in the south-western parts to over 1,000 mm in the hilly tracts of Siwalik hills.

Natural Vegetation

In the state, indigenous trees are *shisham* (*Dalbergia sissoo*) and *babul* (*Acacia nilotica*), and shrub jungle consists of *jal* (*Salvadora oleoides*), *jand* (*Prosopis cineraria*) and coral flowered leafless *karir* (*Capparis aphylla*).

Forest area is limited to 166,000 ha (3.7% of TGA), out of which 76% is classified as protected and 17% as reserve forest.

Soils

These are developed on the alluvium in the plains, and on the detrital and

alluvial materials in the northern sub-mountains tracts, on Aeolian material in the extreme western fringe and on the alluvium modified by Aeolian activity in the southern and south-western part of the state. Inceptisols predominate, occupying about 58% area, followed by Entisols (28%), Aridisols (9%) and Alfisols (2%). Fine, loamy, Typic Ustochrepts are found in Ambala, Karnal, Kurukshetra, Sonepat and Yamunanagar, but at places, these suffer from salinity and sodicity/ high *p*H. Fine, loamy soils dominate state covering 43% of the area. The coarse loamy soils cover 34% and sandy soils 25% of the total area (Sachdeva *et al.,* 1995).

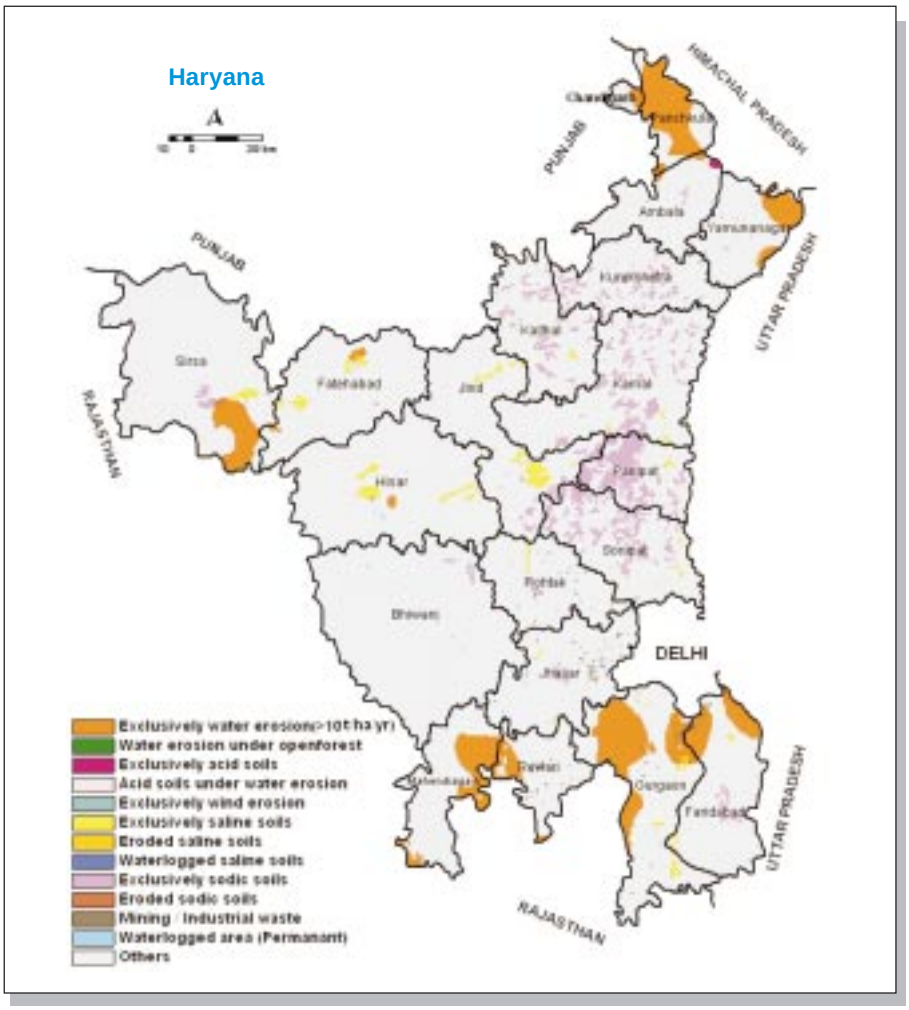

Fig. 20. Degraded and wastelands of Haryana
Source: NBSS&LUP

Table 21. Degraded and wastelands statistics of Haryana (Area in '000 ha)

Districts (19)	Degraded and wastelands classes*													Others**	Total
	1	2	3	4	6	7	8	12	13	14	18	19	Total of classes		
Ambala	3	0	2	0	0	0	0	0	1	0	0	0	6	151	157
Bhiwani	0	0	0	0	0	0	0	0	2	0	0	1	3	475	478
Faridabad	30	0	0	0	0	2	0	0	5	0	1	0	38	177	215
Fatehabad	3	0	0	0	0	5	1	0	0	0	0	0	9	244	253
Gurgaon	77	0	0	0	0	4	1	0	0	0	2	0	84	191	275
Hisar	2	0	0	0	0	10	0	0	0	0	0	1	13	386	399
Jhajjar	0	0	0	0	0	1	0	0	1	0	3	1	6	177	183
Jind	0	0	0	0	0	12	0	0	13	0	0	0	25	245	270
Kaithal	0	0	0	0	0	1	0	0	20	0	0	0	21	211	232
Karnal	0	0	0	0	0	1	0	0	28	0	0	0	29	222	251
Kuruk-shetra	0	0	0	0	0	0	0	0	16	0	1	0	17	136	153
Mahen-dragarh	42	0	0	0	0	0	0	0	0	0	0	0	42	143	185
Panchkula	59	0	0	0	0	0	0	0	0	0	0	0	59	30	89
Panipat	0	0	0	0	0	1	0	0	49	0	0	0	50	78	128
Rewari	20	0	0	0	0	0	0	0	0	0	2	0	22	136	158
Rohtak	0	0	0	0	0	1	0	0	2	0	1	0	4	170	174
Sirsa	36	0	0	0	0	4	0	0	6	1	0	0	47	381	428
Sonipat	0	0	0	0	0	1	0	0	39	0	1	0	41	172	213
Yamuna-nagar	31	0	0	0	0	1	0	0	1	0	1	1	35	145	180
Total	303	0	2	0	0	44	2	0	183	1	12	4	551	3,870	4,421

Notes: Classes*: **1** Exclusively water erosion (>10 tonnes/ha/yr); **2** Water erosion under open forest; **3** Exclusively acid soils; **4** Acid soils under water erosion; **6** Exclusively wind erosion; **7** Exclusively saline soils; **8** Eroded saline soils; **12** Water logged saline soils; **13** Exclusively sodic soils; **14** Eroded sodic soils; **18** Mining/Industrial waste; 19 Waterlogged area (Permanent)
Others**: Normal agricultural lands, water-bodies, rivers, lakes and habitats etc. (based on the limited reconnaisance survey)
Source: NBSS&LUP

Land Use

Major part of the state falls under the most fertile tract of the Indo-Gangetic alluvial plain, where 78% of population is engaged in agriculture. The main food crops are pearl millet, rice and maize during *kharif* and wheat and chickpea in *rabi*. Important commercial crops are sugarcane, cotton and rapeseed and mustard.

Degraded and Wastelands

Total degraded and wastelands are spread in about 551 thousand ha (about 11% of TGA). Water erosion accounts for 303 thousand ha (about 7% of TGA), followed by sodicity, affecting 183 thousand ha (about 3.7% of TGA) and salinity, affecting 46 thousand ha (about 0.9% of TGA) (Fig.20; Table 21).

Total area affected by water erosion in the state is 303 thousand ha. Gurgaon (77 thousand ha), Panchkula (59 thousand ha), Mahendragarh (42 thousand ha), Sirsa (36 thousand ha), Yamunanagar (31 thousand ha) and Faridabad (30

thousand ha) are the worst affected districts. About 2 thousand ha is affected by soil acidity. Small patches have problem of wind erosion also. Saline and sodic soils (both eroded and uneroded) occur to the extent of 4.6% of the TGA of the state. Districts highly affected by salinity are Jind (12 thousand ha), Hisar (10 thousand ha) and Fathehabad (6 thousand ha). Sodicity affected area occurs in Panipat (49 thousand ha), Sonepat (39 thousand ha), Karnal (28 thousand ha) and Kaithal (20 thousand ha). Highly degraded districts are Gurgaon (84 thousand ha), Panchkula (59 thousand ha) and Panipat (50 thousand ha).

Himachal Pradesh

Location

The state is situated between 31°22′40″ to 33°12′40″ N latitudes and 75°45′55″ to 79°04′20″ E longitudes covering 5.56 M ha (55,673 km^2). It is bounded by Jammu and Kashmir in the north, Punjab and Haryana in the south, Uttar Pradesh in the south-east and China in the east.

Physiography

The area can be broadly divided into five major physiographic regions. The major physiographic zones are, greater Himalayas, which run along the eastern boundary with altitude of 5,000–6,500 m; the lesser Himalayas with an attitude of 2,000–5,000 m; the outer Himalayas or Siwaliks with elevation of above 600 m; and piedmont plains that lie below Siwaliks and flood plains.

Geology

In the higher Himalayan zone, granite rocks and granite gneiss are well outcropped intermittently within metamorphosis. In the Tibetian Himalayan zone, youngest Mesozoic formation is exposed in the central parts of the basin.

Climate

The state has diverse climatic conditions due to elevation variations from 350 to 7,000 m. Its climate varies from hot and sub-humid tropical in the southern lower tract to temperate, cold alpine and glacial in the northern and eastern high mountains. The mean annual rainfall ranges from 350 to 3,800 mm. The temperature in the state ranges from 25°to 42°C and average annual temperature is 19.5°C and minimum temperature is 4.4°C. The highest monthly maximum temperature is experienced in June. Thereafter, temperature falls continuously.

Natural Vegetation

Himachal Pradesh has diversified and rich flora owing to diverse climatic

and altitudinal zones: tropical and sub-tropical (elevation 300–1,525 m), temperate (elevation 1,525–3,650 m) and alpine (elevation 3,650–4,650 m). The tree line reaches at about 3,950 m, beyond which Himalayan meadows are found. The snow-line occurs at about 4,600 m. Coniferous forests comprise *chir, deodar, kail*, spruce, silver fir and *chilgoza* pine (*Pinus gerardiana*). Broad-leaved forests contain *sal, ban, mohru,* oak*, kharsa*, walnut, maple, birch, cherry, horse-chestnut, poplar, alder, *sembal, tun* and *shisham*. Generally the order of important timber species growing in the region is *sal, chir, deodar, kail*, spruce and silver fir.

Soils

The soils of the state belong to 4 orders, 6 suborders, 12 great groups and 17 subgroups. Entisols occupy the largest area (51%), followed by Inceptisols (20%), Mollisols (<1%) and Alfisols (<1%). The rock outcrops and glaciers also occupy a major chunk (28%) of the TGA of the state. Among the Entisols, the Udorthents constitute the major part (33%), followed by Cryorthents (15%), Ustifluvents (2%), Udifluvents (1%), Ustorthents (<1%) and Ustipsamments (<1%). Among Inceptisols, Eutrochrepts occupy the highest area (17%), followed by Ustochrepts (1%), Dystrochrepts (<1%) and Cryochrepts (<1%) (Sidhu *et al.,* 1997).

Land Use

The state is a mountainous state with an area of 5,567 thousand ha. Out of the TGA, 19% is under forests, 20% is under pastures and 10% is the net sown area. The remaining 50% is fallow land or non-agricultural area.

The main crops grown in *rabi* are wheat, barley, chickpea and pulses, and in *kharif* are maize, paddy, ragi, millets and pulses; and apple orchards are a prominent feature of the state. There is a perceptible higher yield of almost all the major crops, which may be owing to the adoption of the latest know-how of agricultural technologies, introduction of high-yielding varieties and favourable weather.

Degraded and Wastelands

The total degraded lands account for 1,065 thousand ha (19% of the TGA). Soil loss due to water erosion was found to affect 941 thousand ha (about 18% of TGA). Soil acidity was found in 76 thousand ha (about 1.3% of TGA), and waterlogged and marshy area was found to be 4 thousand ha. Kangra (206 thousand ha) is highly affected by water erosion, followed by Mandi (165 thousand ha), Shimla (159 thousand ha) and Chamba (97 thousand ha). Soil acidity is found highest in Chamba, followed by Kangra and Mandi. The highly

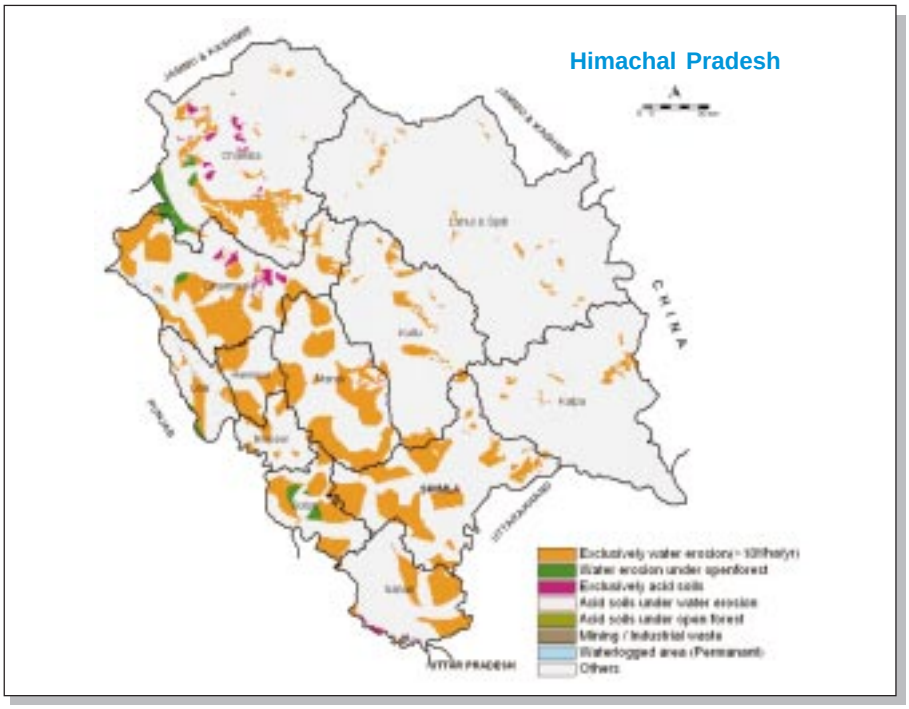

Fig. 21. Degraded and wastelands of Himachal Pradesh
Source: NBSS&LUP

Table 22. Degraded and wastelands statistics of Himachal Pradesh (Area in '000 ha)

Districts (12)	Degraded and wastelands classes*								Others**	Total
	1	2	3	4	5	18	19	Total of classes		
Bilaspur (H)	20	0	0	0	0	0	0	20	96	116
Chamba	77	20	13	17	1	0	0	128	528	656
Kangra	201	5	16	6	0	0	1	229	347	576
Hamirpur	52	0	0	0	0	0	0	52	60	112
Kinnaur	18	0	0	0	0	0	0	18	620	638
Kullu	51	0	0	0	0	0	0	51	497	548
Lahul and Spiti	18	0	0	0	0	0	0	18	1,360	1,378
Mandi	165	0	0	15	0	0	0	180	216	396
Sirmaur	70	0	5	3	0	0	0	78	206	284
Shimla	159	0	0	0	0	0	0	159	354	513
Solan	78	13	0	0	0	0	0	91	104	195
Una	32	5	0	0	0	1	3	41	114	155
Total	941	43	34	41	1	1	4	1,065	4,502	5,567

Notes: Classes*: **1** Exclusively water erosion (>10 t/ha/yr); **2** Water erosion under open forest; **3** Exclusively acid soils; **4** Acid soils under water erosion; **5** Acid soils under open forest; **18** Mining/Industrial waste; **19** Waterlogged area (Permanent)
Others**: Normal agricultural lands, water-bodies, rivers, lakes and habitats etc. (based on the limited reconnaisance survey)
Source: NBSS&LUP

land degraded districts are: Kangra (229 thousand ha), Mandi (180 thousand ha), Shimla (159 thousand ha) and Chamba (128 thousand ha) (Fig. 21, Table 22).

Jammu and Kashmir

Location

The state is located in the north-western part of India, covering 22.2 M ha (222,236 km^2), and is situated between 32°15′ to 37°05′ N latitudes and 72°35′ to 80°20′ E longitudes. The state has international boundary with Afghanistan in the north-west, Pakisthan in the west, China in the north-east; and states of Punjab and Himachal Pradesh border it in the south.

Physiography

The state can be divided into five physiographic regions: Trans Himalayas, Greater Himalayas, Lesser Himalayas, Siwaliks and Plains.

The Trans Himalayan region has an elevation of 6,000 m above msl; Ladakh is situated in this region. The Greater Himalayas include ranges of Karakoram, Ladakh, Zanskar and Himadri; the peaks range from 4,500 to 6,000 m. The lesser Himalayas comprise Kashmir and Pir Panjal ranges; and its elevation varies from 1,600 to 3,500 m above msl. The Siwalik tract lies between Chenab and Ravi rivers and is mostly ravinous land. The narrow strip of plain is situated in the western part of Jammu and Kashmir, bordering Pakistan.

Geology

The state represents mixed geological formations, ranging from Archaeans to recent crystalline rocks like granite and gneisses of Archaean's age. These formations occur mainly in the Zanskar range, Gilgit, Baltistan and Ladakh. Limestone and shale are found extensively in the Karakoram range. Foot-hill plains and valleys are formed from alluvium deposits.

Climate

The state can be divided into four climatic zones: cold arid zone (Ladakh region), temperate zone (Kashmir valley and Pir Panjal region), sub-tropical temperate transitional zone (Punch, Bhadarwah and Kishtwar regions) and low altitude sub-tropical zone (Foot-hill plains and Siwalik hills of Jammu region) (Rana *et al.*, 2000).

The cold zone represents high altitude areas of Himalayas, where the mean summer temperature ranges between 10° and 16°C and winter temperature between –8° and 1°C.

The coldest month in the temperate zone is January when temperature

drops below 0°C; its mean annual temperature is 13.3°C, and mean winter and summer temperatures are 2.7°C and 20.7°C. Jammu region experiences warmer environment with mean annual temperature of 24°C, and mean summer and winter temperatures of 32°C and 8°C.

Natural Vegetation

It varies from Himalayan meadows in the high altitudes above snow-line to evergreen conifers on the gentler slopes of the higher ranges and to scrub jungle at the foot-hills to deciduous forests at the lower southern slopes of the Pir Panjal. Some common species encountered in the foot-hills are *Dalbergia sissoo, Ficus* sp., *Acacia nilotica, Zizyphus* sp., *Euphorbia* spp. etc. Common species in the middle hill ranges (1,500–2,000 m above msl) are *Pinus* sp., *Cedrus* sp., *Juglans regia, Populus* sp. and *Salix* sp. The species found in the high hills (>2,000 m above msl) are *Aesculus indica, Acer caesium, Salix* sp., *Anemone* sp., *Gentiama* sp. and *Betula utilis.* Ladakh region is generally devoid of vegetation, excepting stunted cedrus and willows found in moist strips.

Soils

The soils have been classified in 4 orders, 9 suborders, 15 great groups, 27

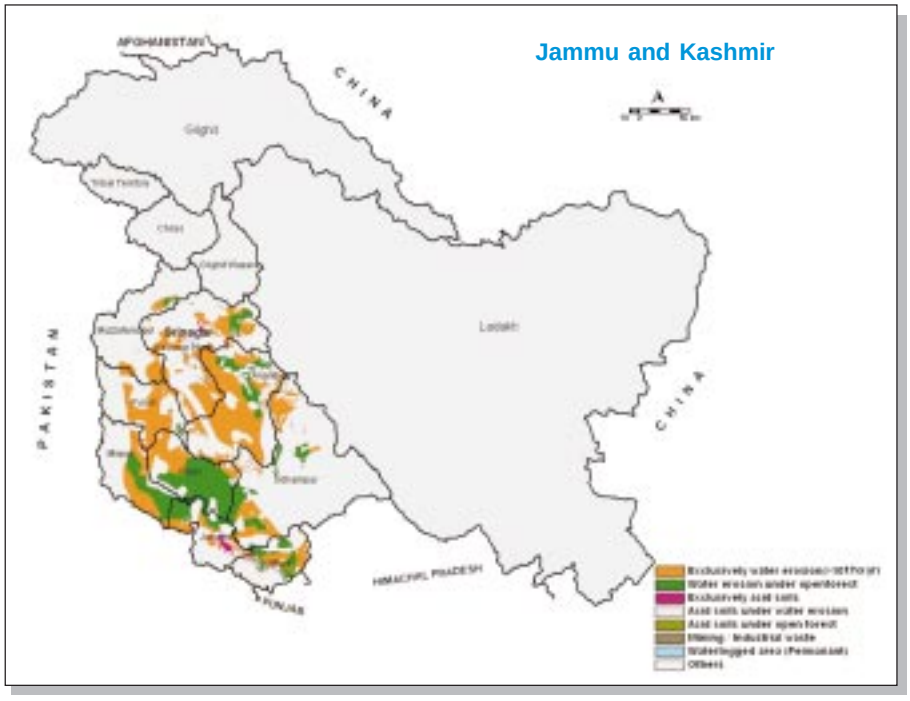

Fig. 22. Degraded and wastelands of Jammu and Kashmir
Source: NBSS&LUP

Table 23. Degraded and wastelands statistics of Jammu and Kashmir (Area in '000 ha)

Districts (14)	Degraded and wastelands classes*								Others**	Total
	1	2	3	4	5	18	19	Total of classes		
Anantnag	337	74	0	0	0	0	1	412	318	730
Chilas	0	0	0	0	0	0	0	0	422	422
Gilghit	0	0	0	0	0	0	0	0	3482	3,482
Gilghit Wazara	0	0	0	0	0	0	0	0	437	437
Jammu	55	70	14	12	0	0	0	151	149	300
Kashmir North	257	36	4	11	0	1	13	322	614	936
Kathua	51	47	2	8	14	0	0	122	146	268
Ladakh	0	0	0	0	0	0	0	0	12056	12,056
Mirpur	116	91	0	4	0	0	0	211	213	424
Muzzafarabad	66	8	0	0	0	0	0	74	551	625
Punch	165	5	1	2	0	0	0	173	255	428
Riasi	123	244	0	5	1	0	0	373	95	468
Tribal Territory	0	0	0	0	0	0	0	0	273	273
Udhampur	157	99	0	0	0	0	0	256	1119	1375
Total	1,327	674	21	42	15	1	14	2,094	20,130	22,224

Notes: Classes *: **1** Exclusively water erosion (>10 tonnes/ha/yr); **2** Water erosion under open forest; **3** Exclusively acid soils; **4** Acid soils under water erosion; **5** Acid soils under open forest; **18** Mining/Industrial waste; **19** Waterlogged area (Permanent)
Others**: Normal agricultural lands, water-bodies, rivers, lakes and habitats etc. (based on the limited reconnaisance survey)
Source: NBSS&LUP

subgroups and 66 soil families. Entisols are observed to be the dominant soil, covering around 34% of TGA, followed by Inceptisols (6%), Alfisols (<1%) and Hollisols (<1%). Different soil subgroups in the state are Typic Hapludalfs, Aquic Hapludalfs and Lithic Cryorthents (Rana *et al.*, 2000).

Land Use

In the state about 4% area is under cultivation; 4% of this is irrigated and the rest is rainfed. And it has 13% area under forest and fruit trees. Maize and paddy are the principal crops, occupying 53% of the gross cropped area, followed by wheat (24%), oilseeds (7%) and pulses (4%); the remaining area is under barley, millets and other cereal crops.

Degraded and Wastelands

Jammu and Kashmir major problem is of water erosion. Total degraded lands account for 2,094 thousand ha (9% of TGA) and area affected by erosion is 2,001 thousand ha (about 9% of TGA). Worst affected districts by erosion are Anantnag (411 thousand ha), Riasi (367 thousand ha), Kashmir North (293 thousand ha), Udhampur (256 thousand ha) and Mirpur (207 thousand ha). Soil acidity has affected about 78 thousand ha; confined to Jammu (26 thousand ha), Kathua (24 thousand ha) and Kashmir North (15 thousand ha) (Fig. 22; Table 23).

Severally affected districts by land degradation are: Anantnag (412 thousand ha), Riasi (373 thousand ha), Kashmir North (322 thousand ha) and Udhampur (256 thousand ha).

Punjab

Location

The state with an area of 5.03 M ha (50,362 km^2) lies between 29°30′ and 32°32′N latitudes and 73°55′ and 76°55′E longitudes. It is bounded by Pakistan in the west, Jammu and Kashmir in the north, Himachal Pradesh in the north and north-east, Haryana in the east and south-west and Rajasthan in the south-west.

Physiography

The state has three major physiographic regions: Siwalik hills, Piedmont plain and Alluvial plain. These have been further subdivided into: Siwalik hills, Piedmont plain, Recent Alluvial plain, Alluvial plain with sand-dunes and Aeo-fluvial plains. The general slope of the state is from north-east to south-west. Elevation varies from about 180 to 300 m above msl in the plains and from 300 to 700 m above msl in the hilly tracts of the Siwaliks.

Geology

Geologically Punjab is composed of Siwaliks and recent alluvium. The Siwalik hills bordering the state in the north are composed of sedimentary deposits of sandstone, shales and of conglomerates belonging to Upper Miocene to Lower Pleistocene period. The entire state to the south of Siwalik hills comprises alluvial plain of the Satluj, Beas, Ravi and Ghaggar rivers, covering about two-thirds of the TGA. These deposits belong to Pleistocene and recent period.

Wind blown sands are deposited in the form of sandy plains and sand-dunes over alluvial deposits in the southern parts of Bathinda, Faridkot and Firozpur adjoining Haryana and Rajasthan.

Climate

The climate is predominantly sub-tropical, semi-arid and monsoonic type. Mean summer temperature ranges from 31° to 37°C and winter temperature varies from 13° to 16°C, and the mean annual temperature is 24°C. Mean annual rainfall varies from 700 to 1,200 mm.

Natural Vegetation

It consists of following trees: *shisham* (*Dalbergia sissoo*), *babul* (*Acacia nilotica*), *ber* (*Zizyphus jujuba/mauritiana*), *jant* (*Prosopis cineraria*), *tut* (*Morus alba*), *neem*

(*Azadirachta indica*), *pipal* (*Ficus religiosa*), and *bohar* (*Ficus bengalensis*). And common species of shrubs and grasses are: *sarkanda* (*Saccharum munja*), *jal* (*Salvadora oleoides*), *bhang* (*Cannabis sativa*), *aak* (*Calotropis procera*), *jharberi* (*Zizyphus nummularia*), *dhaman* (*Cenchrus* sp.), *dub* (*Cynodon dactylon*), *bathu* (*Chenopodium album*), *pohali* (*Solanum xanthocarpum*), *motha* (*Cyperus rotundus*) and *satyanashi* (*Argemone mexicana*).

The forest cover of the state is only 4% of its area as against the national average of 19.4%, forests are confined mostly along with the canals, roads and village common lands.

Soils

The soils have developed into alluvium, showing varied degrees of development. They belong to 4 orders (Inceptisols, Entisols, Aridisols and Alfisols). Inceptisols are predominant, covering 50% of the total area, followed by Entisols, Aridisols and Alfisols, covering 20%, 16% and 4%. The subgroups of Usotchrepts, Camborthids, Ustipsamments and Ustifluvents are widely distributed in the state (Sidhu *et al.,* 1995).

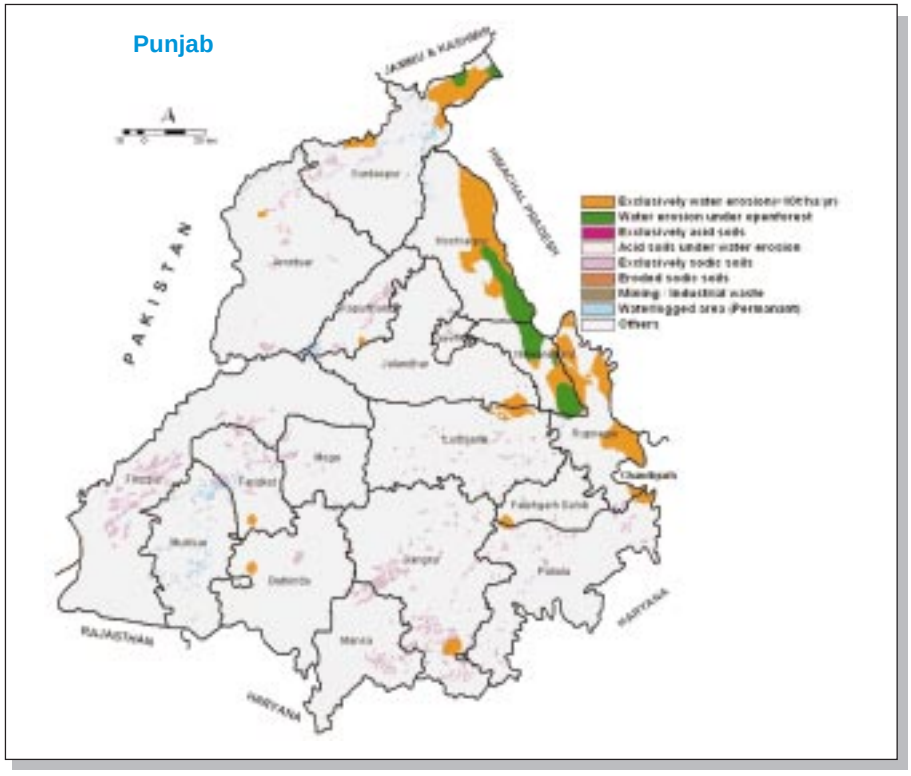

Fig. 23. Degraded and wastelands of Punjab
Source: NBSS&LUP

Table 24. Degraded and wastelands statistics of Punjab (Area in '000 ha)

Districts (17)	Degraded and wastelands classes*								Others**	Total
	1	2	3	13	14	18	19	Total of classes		
Amritsar	1	0	0	11	0	0	3	15	497	512
Bathinda	2	0	0	3	0	0	0	5	334	339
Faridkot	2	0	0	11	0	0	2	15	133	148
Fatehgarh Sahib	3	0	0	0	0	0	0	3	115	118
Firozpur	0	0	0	29	0	0	1	30	503	533
Gurdaspur	36	7	0	8	0	0	9	60	295	355
Hoshiarpur	82	34	0	0	0	0	3	119	208	327
Jalandhar	4	0	0	1	0	0	0	5	259	264
Kapurthala	1	0	0	9	0	0	3	13	151	164
Ludhiana	8	0	0	2	0	5	0	15	363	378
Mansa	0	0	0	13	0	0	0	13	205	218
Moga	0	0	0	6	0	0	0	6	217	223
Muktsar	0	0	0	2	0	0	13	15	247	262
Nawanshahr	15	32	0	0	0	0	0	47	72	119
Patiala	5	0	0	14	0	0	0	19	346	365
Rupnagar	63	1	0	2	0	0	0	66	136	202
Sangrur	6	0	0	40	1	1	0	48	461	509
Total	228	74	0	151	1	6	34	494	4,542	5,036

Notes: Classes*: **1** Exclusively water erosion (>10 tonnes/ha/yr); **2** Water erosion under open forest; **3** Exclusively acid soils; **13** Exclusively sodic soils; **14** Eroded sodic soils; **18** Mining/Industrial waste; **19** Waterlogged area (Permanent)
Others**: Normal agricultural lands, water-bodies, rivers, lakes and habitats etc. (based on the limited reconnaisance survey)
Source: NBSS&LUP

Land Use

Punjab is principally an agricultural state; about 60% of the total working population is engaged in agriculture and contributes towards 50% of state's income. The main crops grown are wheat, mustard and chickpea in *rabi* and paddy, cotton, maize and millets in *kharif.* Crop rotations followed mainly are rice-wheat, rice-wheat-maize, rice-potato-wheat, rice-wheat-maize-summer mungbean, wheat-cotton and mustard-cotton.

Degraded and Wastelands

Total degraded and wastelands in the state account for 494 thousand ha (about 9% ot TGA). Highly degraded districts are: Hoshiarpur (119 thousand ha), followed by Rupnagar (66 thousand ha), Gurdaspur (60 thousand ha), Nawanshahr (47 thousand ha) and Sangrur (48 thousand ha) (Fig. 23, Table 24).

The trend of land degradation in Punjab is similar to that of Haryana. Water erosion is the main degradational process. It covers 302 thousand ha (about 6% of TGA). Notably districts affected by water erosion are Hoshiarpur (116 thousand ha), Rupnagar (64 thousand ha), Nawanshahr (47 thousand ha) and Gurdaspur (43 thousand ha). Neglegible erosion is observed in Firozpur, Mansa,

Moga and Muktsar. Sodic soils account for 152 thousand ha and eroded sodic soils account for 1 thousand ha. Sodicity affected soils are existing almost in all districts except Faridkot, Hoshiarpur and Nawanshahr. Highly sodic soils affected districts are Sangrur (41 thousand ha), Firozpur (29 thousand ha), Patiala (14 thousand ha), Mansa (13 thousand ha), Faridkot and Amritsar (11 thousand ha each). Total waterlogged area amounts to 34 thousand ha, of which Muktsar has 13 thousand ha and Gurdaspur has 9 thousand ha.

Uttar Pradesh

Location

Uttar Pradesh is located between 23°52′ to 31°28′ N latitudes and 77°06′ to 84°37′ E longitudes with an area of 23.8 M ha (238,566 km^2). It is the fourth largest state in India and is a land locked state bounded by China and Nepal in the north, Himachal Pradesh in the north-west, Haryana and Delhi in the west, Rajasthan in the south-west, Madhya Pradesh and Chhattisgarh in the south, Jharkhand in the south-east and Bihar in the east.

Physiography

The state has three distinct physiographic divisions: the Himalayas, the Gangetic plains; the southern highlands, plateaux and scarplands.

The Gangetic plains lie between Himalayas on the north side and highlands, plateaux and scarplands on the south side. The Great Ganga plain covers almost 70% area of the state. Piedmonts and *tarai* are the most significant and complex part of the Gangetic plains in the submontane belt running along the foot of Siwaliks from west to east. Alluvial plain is a riverine plain and is featureless. Its monotony is broken by red-stone hillocks of Aravalli hills on the western part of Mathura district, and on the micro-level by the river bluffs, levees and dead arms of river channels. The Aravalli plain constitutes a discontinuous central hilly sub-surface tract of the Aravallis. The southern highlands, plateaux and scarplands comprise eastern Rajasthan uplands, Bundelkhand uplands, Vindhyan scarplands and Eastern Plateau. Eastern Rajasthan uplands are formed by the riverine action of the Banas and Mahi rivers. These originate from Aravalli ranges. Bundelkhand uplands and Vindhyan scarplands are located in the south of Gangetic plains; the region forms a part of the foreland of the Deccan Peninsula. The western part of this tract is known as Bundelkhand and eastern part forms natural division known as Vindhyas. The Eastern plateau is peneplained surface with a rugged topography. It includes rounded hills with rolling dissected plateaux.

Geology

The Gangetic plains are characterized by an almost imperceptible change in elevation and uniform river-line material. The pre-tertiary river-borne material from the peninsula has later been supplemented rather more vigorously by the upper and post-tertiary Himalayan materials.

The south-western region of the state is largely composed of crystalline igneous and metamorphic rocks. The typical rock of this region is popularly termed as 'Bundelkhand gneiss'. In fact granite and gneiss both are conspicuous in which former predominates. The Vindhyan scarplands in the south-eastern part comprise Vindhyan and Kaimur sandstone, shales and mixed conglomerates. However, the plain within the region is formed by the alluvium deposited by the rivers of the central highlands.

Climate

It is, in general, subtropical, continental, monsoonic, with mild and dry winters and hot uncomfortable summers. Rainfall is orographic in nature, and is caused by the obstruction of the high mountain wall in the north to the monsoon. June to September is the rainy season during which 88% of the total annual rainfall is received. Northern districts adjacent to foothills of Himalayas constitute area of maximum rainfall (>1,400 mm), and the districts adjacent to east Rajasthan receive minimum rainfall (<600 mm).

April, May and June are the summer months when hot winds (the *loo*) blow from the west. May is the hottest month with mean maximum temperature of 41°C in the Gangetic plains. However, Plateau region and elevated places, in general, record 2° to 5°C lower temparature. January is coldest with mean minimum temperature ranging from 6.5° to 10°C. The north-western districts experience extreme cold during winters. Hailstorms in February and March are not uncommon.

Natural Vegetation

Lower regions have several species interspersed with bamboos, climbers, and evergreen shrubs. The dominant species of the state are *sal, gular, jhingal, pipal, shisham*. Widely scattered thorny trees, mainly, thorny legumes, euphorbias and dwarf grass species are found extensively. The trees are generally stunted, forming open dry forest. Important trees of the region are *phulai, khair, kokke, dhaman.*

Soils

Soils of Glacio-Fluvial Valleys are moderately shallow, excessively drained, coarse-loamy, slightly acidic, and are moderately stony. Typic Udorthents are

found in association with rock outcrops. The lower valley slopes are occupied with moderately shallow, well-drained, sandy-skeletal/coarse-loamy, slightly acidic, slightly eroded and strongly stony soils with low water-holding capacity. These are classified as Typic Udorthents.

Soils of Piedmont plain are deep, well-drained, neutral to slightly alkaline, coarse-loamy/fine-loamy (calcareous/non-calcareous), Udic Haplustepts that occur in association with deep, well-drained, neutral to slightly acidic coarse-loamy over fragmental and fine-loamy over sandy, Udifluventic Haplustepts. At places, soils are deep and excessively drained Typic Udipsamments, and fine-silty, Udic Haplustolls have also been noticed.

Soils of *tarai* are dominantly very deep, well-drained, slightly alkaline, coarse-loamy/fine-loamy, Udic Haplustepts. The other soils are mapped as coarse-loamy (calcareous), Udic Haplustolls and fine-loamy over sandy-skeletal, Udifluventic Haplustepts. These soils are rich in organic matter, plant nutrients and have fairly good water-holding capacity.

Soils of sandstone landscape are shallow to moderately shallow, somewhat excessively drained, loamy-skeletal, Lithic/Typic Ustorthents.

The intervening basin on the other hand is occupied with deep, moderately well-drained, fine (montmorillonitic), Vertic Haplustepts and Entic Haplusterts. The other soils mapped are moderately shallow to deep, well to moderately well-drained, fine-loamy (calcareous/non-calcareous), Typic Haplustepts.

The soils of the state belong to 5 orders, 11 suborders, 21 great groups and 41 subgroups. Nearly 70% of area is under Inceptisols, followed by Entisols (19%), Alfisols (5%), Vertisols (2%) and Mollisols (<1%). The total area under mapping units is 99%, and the rest (1%) is under miscellaneous soils (Singh *et al.,* 2003).

Land Use

The changes in the land use pattern over passage of time have revealed that of the total geographic area of 24 M ha, the cultivated area is about 18,600 thousand ha (62%). It comprises 17,500 thousand ha as net sown area that is irrigated area also, and about 1,000 thousand ha as the current fallows. The net sown area increased from 16,200 in 1950–51 to 17,500 thousand ha in 1971; and since then till 1997–98 showed no further increase. That increase was largely due to the extension of cultivation on the marginal lands including culturable wastes and lands under miscellaneous trees and groves. About 1,800 thousand ha (6%) of the area is under fallow, which is either due to the lack of irrigation facilities or related problems of waterlogging, salinity/sodicity.

Although unculturable and culturable wastelands have declined significantly over the time, yet they accounted nearly 10% in 1997–98, indicating

that nearly 6% of the land in the state is not being put to productive use. Due to uncontrolled and unplanned urbanization and industrialization, area under non-agricultural uses has increased continuously from 1,800 thousand ha (6.3%) in 1951–52 to 2,500 thousand ha (8.5%) in 1997–98, indicating conversion of prime agricultural lands for non-agricultural purposes.

Degraded and Wastelands

The soils are highly susceptible to degradation by water erosion, covering 12,884 thousand ha (54% of TGA of the state). Almost all districts are affected barring Gautam Buddhanagar and Bareilly. The highly affected districts are: Lakhimpur Kheri (468 thousand ha), Sondhara (437 thousand ha), Jhansi (426 thousand ha), Lalitpur (416 thousand ha), Baharaich (406 thousand ha) and Allahabad (381 thousand ha). Banda, Agra, Bijnor, Hamirpur, Mirzapur, Sultanpur and Saharanpur each has more than 300 thousand ha area affected by water erosion (Fig. 24; Table 25).

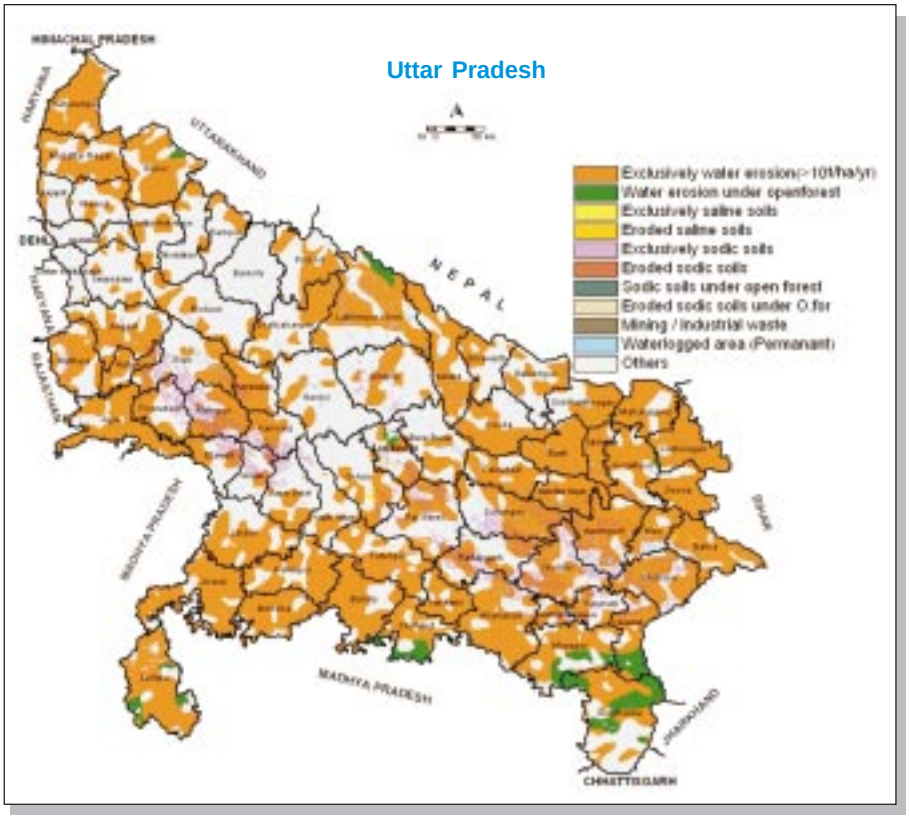

Fig. 24. Degraded and wastelands of Uttar Pradesh
Source: NBSS&LUP

Table 25. Degraded and wastelands statistics of Uttar Pradesh (Area in '000 ha)

Districts (70)	Degraded and wastelands classes*											Others**	Total
	1	2	7	8	13	14	16	17	18	19	Total of classes		
Agra	333	0	0	0	2	1	0	0	0	0	336	63	399
Aligarh	206	0	0	0	4	12	0	0	0	4	226	145	371
Allahabad	381	0	0	0	19	16	0	0	0	8	424	115	539
Ambedkar Nagar	194	0	0	0	0	24	0	0	0	3	221	14	235
Auraiya	17	0	0	0	37	18	0	0	0	0	72	132	204
Azamgarh	244	0	0	1	32	68	0	0	0	11	356	64	420
Baghpat	23	0	0	0	0	0	0	0	0	0	23	113	136
Baharaich	406	0	0	0	0	0	0	0	0	10	416	153	569
Ballia	236	0	0	6	5	6	0	0	0	3	256	40	296
Balrampur	109	1	0	0	0	0	0	0	0	1	111	178	289
Banda	346	3	0	0	0	0	0	0	0	0	349	89	438
Bara Banki	111	0	0	0	6	2	0	0	0	5	124	253	377
Bareilly	2	0	0	0	0	0	0	0	0	2	4	401	405
Basti	291	0	0	0	0	1	0	0	0	3	295	7	302
Bijnor	308	13	0	0	0	0	0	0	0	0	321	130	451
Budaun	134	0	0	0	2	0	0	0	0	1	137	373	510
Bulandshahar	73	0	0	0	0	0	0	0	0	0	73	293	366
Chandauli	130	66	0	0	7	13	0	0	0	2	218	36	254
Chitrakut	173	68	0	0	0	0	0	0	0	1	242	75	317
Deoria	208	0	0	1	0	1	0	0	0	1	211	42	253
Etah	146	0	0	0	55	24	0	0	0	8	233	208	441
Etawah	73	0	0	0	30	18	0	0	0	0	121	105	226
Faizabad	190	0	0	0	2	5	0	0	0	3	200	74	274
Farrukhabad	153	0	0	0	0	14	0	0	0	0	167	58	225
Fatehpur	282	0	0	0	0	1	0	0	0	3	286	125	411
Firozabad	99	0	0	0	36	7	0	0	0	0	142	92	234
Gautam Buddha Nagar	2	0	0	0	0	0	0	0	0	1	3	122	125
Ghaziabad	30	0	0	0	0	0	0	0	0	3	33	160	193
Ghazipur	201	0	0	0	21	44	0	0	0	6	272	64	336
Gonda	276	0	0	0	0	0	0	0	0	3	279	159	438
Gorakhpur	210	6	0	0	2	10	0	0	0	1	229	100	329
Hamirpur	326	0	0	0	1	0	0	0	0	0	327	101	428
Hardoi	94	0	0	0	0	0	0	0	0	10	104	485	589
Hatras	126	0	0	0	6	13	0	0	0	1	146	29	175
Jalaun	272	0	0	0	0	0	0	0	0	0	272	180	452
Jaunpur	160	0	0	0	56	69	0	0	0	9	294	108	402
Jhansi	426	0	0	0	0	0	0	0	0	0	426	72	498
Jyotiba Phule Nagar	92	0	0	0	1	1	0	0	0	0	94	135	229
Kabirnagar	131	0	0	0	0	2	0	0	0	2	135	8	143
Kannauj	74	0	0	0	36	17	0	0	0	0	127	71	198
Kanpur Dehat	94	0	0	0	31	2	0	0	0	0	127	184	311
Kanpur Nagar	74	0	0	0	10	1	0	0	0	0	85	214	299
Kaushambi	150	0	0	0	0	0	0	0	0	0	150	32	182
Kushinagar	264	1	0	0	0	0	0	0	0	1	266	23	289
Lakhimpur Kheri	432	36	0	0	0	0	0	0	0	23	491	269	760
Lalitpur	367	49	0	0	0	0	0	0	1	0	417	84	501
Lucknow	66	14	5	0	17	20	2	0	0	1	125	126	251
Maharajganj	229	0	0	0	0	0	0	0	0	1	230	63	293
Mainpuri	105	0	0	0	57	63	0	0	0	0	225	49	274

(continued)

(Table 25. concluded)

Districts (70)	Degraded and wastelands classes*											Others**	Total
	1	2	7	8	13	14	16	17	18	19	Total of classes		
Mathura	201	0	0	0	6	12	0	0	0	3	222	108	330
Mau	110	0	0	4	7	7	0	0	0	6	134	37	171
Meerut	89	0	0	0	0	0	0	0	0	0	89	160	249
Mirzapur	245	69	0	0	1	1	0	0	0	1	317	131	448
Mohoba	244	0	0	0	0	0	0	0	0	0	244	38	282
Moradabad	73	0	0	0	0	0	0	0	1	0	74	285	359
Muzaffarnagar	277	0	0	0	0	0	0	0	0	0	277	121	398
Partapgarh	116	0	0	0	34	60	0	0	0	3	213	154	367
Pilibhit	148	0	0	0	0	0	0	0	0	1	149	196	345
Rai Bareli	154	0	0	0	32	39	0	0	0	2	227	226	453
Rampur	63	0	0	0	0	0	0	0	0	1	64	170	234
Saharanpur	306	3	0	0	0	0	0	0	0	0	309	57	366
Sant Ravidas	51	0	0	0	7	10	0	0	0	0	68	26	94
Shahjahanpur	214	0	0	0	0	0	0	0	0	4	218	234	452
Shrawasti	46	0	0	0	0	0	0	0	0	0	46	65	111
Siddharthnagar	160	1	0	0	0	0	0	0	0	2	163	110	273
Sitapur	142	0	0	0	20	9	0	0	0	7	178	388	566
Sondhara	253	184	0	0	0	0	0	0	1	0	438	235	673
Sultanpur	217	0	0	0	26	59	0	0	0	10	312	128	440
Unnao	135	0	4	1	6	11	0	0	0	1	158	292	450
Varanasi	57	0	0	0	12	11	0	0	0	4	84	72	156
Total	12,370	514	9	13	626	692	2	0	3	176	14,405	9,449	23,854

Notes: Classes*: **1** Exclusively water erosion (>10 tonnes/ha/yr); **2** Water erosion under open forest; **7** Exclusively saline soils; **8** Eroded saline soils; **13** Exclusively sodic soils; **14** Eroded sodic soils; **16** Sodic soils under open forest; **17** Eroded sodic soils under open forest; **18** Mining/Industrial waste; **19** Waterlogged area (Permanent).
Others**: Normal agricultural lands, water-bodies, rivers, lakes and habitats etc. (based on the limited reconnaisance survey)
Source: NBSS&LUP

Saline soils cover 22 thousand ha, affecting Balia (6 thousand ha), Unnao (5 thousand ha) and Lucknow (5 thousand ha), and about 1,320 thousand ha (about 6% of TGA) is covered by sodic soils.

Jaunpur (125 thousand ha), Mainpuri (120 thousand ha), Azamgarh (100 thousand ha), Pratapgarh (94 thousand ha) and Sultanpur (85 thousand ha) are affected by sodicity. Other districts where sodicity is encountered are Etah, Gazipur, Auraiya and Kannauj.

Area affected due to mining accounts for 176 thousand ha. Districts having mining wastes are Lakhimpur Kheri, Sultanpur, Hardoi, Azamgarh and Etah.

Uttarakhand

Location

Uttarakhand is situated between 28°43′ to 31°27′ N latitudes and 79°33′ to 83°02′ E longitudes. It lies in the northern part of India amidst magnificent

Himalayas and dense forests with total geographical area of 5.33 M ha (55,845 km^2). The state is bounded by Himachal Pradesh in the north-west and Uttar Pradesh in the south and has international borders with Nepal and China.

Physiography

The state has three distinct physiographic divisions: the Himalayas, the Gangetic plains and the southern highlands, plateaux and scarplands. The Greater Himalayas is a 50-km wide north-western tract of the state, bordering China and Himadri. This zone is highly rugged, dissected and difficult with precipitious snow-clad slopes, reliefs average between 4,800 and 6,000 m above mean sea level. These ranges act as a barrier to the oncoming eastern and southern monsoons. In this lies towering majestic mountain peaks of the Nanda Devi (7,817 m), Kamet (7,756 m), Badrinath (7,138 m), Trishul (7,120 m), Dunagiri (7,066 m), Kedar Nath (6,940 m), Nanda Hat (6,861 m), Gangotri (6,614 m) and Bandar Bunch (6,315 m).

The Lesser Himalayas lies between south of Greater Himalayas and north of Siwaliks. This is a massive mountainous tract of series of ridges being divided from one another by deep valleys. The average relief of the ridges in this zone ranges between 1,500 and 2,700 m and valley bottoms between 500 and 1,200 m above mean sea level. Many hill stations Naini Tal, Mussorie, Lansdowne and Chakrata are situated in these ranges.

The Siwaliks (the Outer Himalayas) lie immediately below and between south of Lesser Himalayas and north of Gangetic plains. These are situated almost parallel to major ranges of Lesser Himalayas, with an average height of 300–900 m above msl, stretching in the north-west–south-east direction and forming outer ranges of the Himalayan system. However, the Siwalik ranges have sharp-edged crest between 750 and 1,200 m above msl. On the southern slopes, Siwaliks have steep scarps while on the north they descend gently to flat-floored structural valleys called *Duns*. Important *Duns* are Dehra, Kohtri, Chaukhamba, Patti and Kota. Dehra is the biggest and a well developed *Dun* of Siwaliks.

Geology

Geologically, the Himalayan mountains fall into three broad stratigraphical zones: Higher Himalayan zone, of a series of highly fossiliferrous sediments; Lower Himalayan zone of granite and other crystalline rocks of unfossiliferous sediments, and Outer Himalayan zone of sediments, mostly of tertiary age.

Climate

Himalayan region is subtropical to temperate, sub-humid to per-humid, continental and monsoonic. In this, summers are cool and short while winters

are severe and record frost and snow at the higher altitudes. Rainfall is highly variable due to rugged topography and geographical position of the state. The annual rainfall varies from 970 mm to 2,900 mm and the average number of rainy days in a year vary from 65 to125. Naini Tal, Dehra Dun and Garhwal districts receive maximum rains.

The region being hilly with deep valleys, temperature varies considerably depending on the elevation. Generally, end of May or beginning of June is the hottest period. The mean daily maximum temperature in valleys (with elevation less than 1,000 m above msl) is around 36°C in May and is around 26°C at about 2,000 m and at higher altitudes. With the onset of monsoon, the day temperature falls by about 3° to 5°C; with the withdrawal of monsoon (end of September), day and night temperatures start falling, and touch lowest in January. The mean daily maximum and minimum temperatures in January in the valleys (elevation less than 1,000 m above msl) are 19° and 16°C, and these are 11° and 3°C at an elevation of 2,000 m above msl. During winter cold winds associated with the western disturbances bring down night temperature appreciably, even below the freezing point of water. The greater Himalayan zone experiences cold, dry climate and precipitation, particularly in winters that occurs mainly as snow.

Natural Vegetation

Temperate forests comprise pine and alpine forests at altitudes ranging from 1,600 m to 29,900 m above msl, and includes *deodar*, silver fir, oak, beech and birch mixed with *chinnar*, elm, *Rhododendron*, walnut, mapple etc. The sub-tropical pine forest grows in the lower Himalayan region between Himalayan moist temperate forests and tropical dedicuous forests. Coniferous forests comprise *chir, deodar, kail*, spruce, silver fir and *chilgoza* pine (*Pinus gerardiana*). Broad-leaved forests are of *sal, ban, mohru, oak, kharsa*, walnut, maple, birch, cherry, horse-chestnut, poplar, alder, *semal, tun* and *shisham*. The vegetations, which occurs at higher altitudes are found projected in the lower zone also. Generally the order of important timber species growing in the region is *sal, chir, deodar, kail,* spruce and silver fir.

Soils

Soils of summits and ridge tops are shallow to moderately shallow, excessively drained, sandy/loamy-skeletal/loamy and are exposed to moderate to severe erosion and moderate to strong stoniness. They are classified as Lithic/ Typic Udorthents. Other soil formations are moderately shallow, somewhat excessively drained, fine-loamy/coarse-loamy, Dystric Eutrudepts and Typic Hapludolls with slight to moderate erosion in association with sandy/loamy-skeletal, Typic Udorthents. The soils are slightly to moderately acidic.

Soils of side slopes are very shallow to shallow, excessively drained sandy/loamy-skeletal/loamy without soil development with Lithic contact within 50 cm of the surface (Lithic Udorthents). These are slight to moderately acidic, very severely eroded, strongly stony with low available water capacity (Singh *et al.,* 2003).

Land Use

The state has 93% of its TGA under mountains and hills. About 64% of the area is covered by forests. Agriculture is practised in interhill valleys and terraced lands on moderate steep lands. Wheat, maize and paddy are mainly grown in these areas. Vegetables are grown in the lower altitudes, and potato is an important crop grown here.

Degraded and Wastelands

Trend of degraded and wastelands in the state follows a similar pattern to that of other Himalayan states where soil erosion and soil acidity remain prime

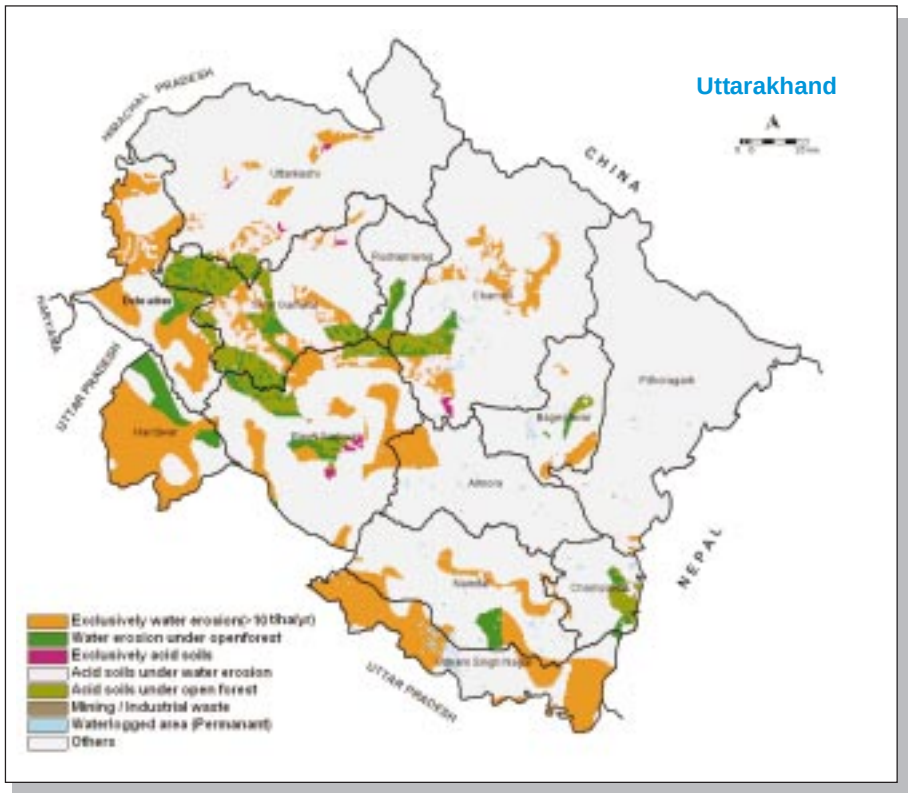

Fig. 25. Degraded and wastelands of Uttarakhand
Source: NBSS&LUP

Table 26. Degraded and wastelands statistics of Uttarakhand (Area in '000 ha)

Districts (13)	Degraded and wastelands classes*								Others**	Total
	1	2	3	4	5	18	19	Total of classes		
Almora	30	0	0	0	0	1	2	33	288	321
Bageshwar	16	4	0	0	4	0	3	27	212	239
Chamoli	65	12	3	28	21	0	6	135	657	792
Champawat	3	9	0	1	20	0	1	34	151	185
Dehra Dun	134	9	0	20	15	0	0	178	147	325
Haridwar	151	36	0	0	0	0	0	187	63	250
Naini Tal	59	14	0	1	0	0	4	78	324	402
Pauri Garhwal	103	30	6	15	35	0	0	189	376	565
Pithoragarh	3	0	0	6	0	0	1	10	727	737
Rudraprayag	1	16	0	0	12	0	0	29	167	196
Tehri Garhwal	52	44	1	78	82	0	0	257	171	428
Udham Singh Nagar	177	1	0	0	0	0	8	186	121	307
Uttarkashi	35	5	3	40	9	0	0	92	743	835
Total	829	180	13	189	198	1	25	1,435	4,148	5,583

Notes: Classes*: **1** Exclusively water erosion (>10 tonnes/ha/yr); **2** Water erosion under open forest; **3** Exclusively acid soils; **4** Acid soils under water erosion; **5** Acid soils under open forest; **18** Mining/Industrial waste; **19** Waterlogged area (Permanent)
Others**: Normal agricultural lands, water-bodies, rivers, lakes and habitats etc. (based on the limited reconnaisance survey)
Source: NBSS&LUP

causes. Total degraded lands account for 1,435 thousand ha affecting 26% of the TGA of the state. Highly degraded districts are: Tehri Garhwal (257 thousand ha), Pauri Garhwal (189 thousand ha), Haridwar (187 thousand ha), Udham Singh Nagar (186 thousand ha) and Dehra Dun (176 thousand ha) (Fig. 25; Table 26).

It has been found that 1,009 thousand ha (about 18% of the TGA) of the state is affected by water erosion. Haridwar is worst affected with 187 thousand ha, and others affected districts are Udham Singh Nagar (178 thousand ha), Dehra Dun (143 thousand ha), Pauri Garhwal (133 thousand ha) and Tehri Garhwal (96 thousand ha).

Soil acidity has remained the second major factor of degradation. Approximately 8% of TGA of the state (400 thousand ha) is affected by acidity. Tehri Garhwal has acidic soils in 161 thousand ha, followed by Uttarkashi (52 thousand ha), Pauri Garhwal (56 thousand ha), Chamoli (52 thousand ha) and Dehra Dun (35 thousand ha).

Waterlogging is a problem in Udham Singh Nagar, Chamoli, Naini Tal, Bageshwar, Almora, Champawat and Pithoragarh.

EASTERN REGION

The eastren region comprises Bihar, Jharkhand, Orissa and West Bengal.

Bihar

Location

Bihar is situated between 24°17′ to 27°31′ N latitudes and 83°20′ to 88°17′ E longitudes, and covers an area of 9.41 M ha (94,163 km^2). It is bounded by Nepal in the north and north-east, West Bengal in the east, Jharkhand in the south-east and south and Uttar Pradesh in the west.

Physiography

The state is divided into Eastern Himalayas, Indo-Gangetic plain, Eastern Plateau (Chhotanagpur) and Central Highlands. Eastern Himalayas comprises subdued hills with sloping Piedmont plain in the north-western corner of the state. Indo-Gangetic plain covers 80% of the state. It extends in the north and south of the river Ganga. Eastern plateau (Chhotanagpur) consists a series of plateaux at different elevations in the southern part of the state. The Central highlands cover parts of Rohtas and is western hilly portion of the state.

Geology

The geological formations comprise the oldest Archean rocks to recent alluvium. The important rock formations are Archean, Vindhyan, Siwalik, late tertiary gravels and alluvium.

Siwalik formations consist of conglomerates and sand rocks. These occur at the extreme north-west of the state in Champaran district. More than 90% of the highland in south Bihar is composed of Archaen rocks comprising granite and gneiss, and partly Dharwarian rocks, partly metamorphic and sedimentary. Vindhyan rocks comprise sandstone, quartzite, limestone, dolomite and shale. These are confined to a small area in the extreme western part of the state, between the Sasaram and the Son river, forming an eastern end of Kaimur plateau. The Gondwana rocks are distributed in the east-west belt parallel to general structural trend of the Archean, and are confined to the direction of Aurangabad and Damodar valley.

Climate

Its climate is sub-humid, subtropical monsoon type. The mean annual rainfall of the state ranges from 1,400 mm near the northern and north-eastern corner to a minimum of 1,000 mm on the western border along the Ganga axis. The mean annual air temperature ranges from 24° to 26°C with a mean winter temperature between 17° and 19°C.

Natural Vegetation

Vegetation is submontane in north Bihar plain, and tropical dry vegetation in central part of the Ganga plain.

Species most commonly found in the forest are: *babul* (*Acacia nilotica*), *bel* (*Aegle marmelos*), *ber* (*Zizyphus jujuba*), *behara* (*Terminalia belerica*), *imli* (*Tamarindus indica*), *jamun* (*Syzygium cumini*), *khair* (*Acacia catechu*), *khajur* (*Phoenix sylvestris*), *mahua* (*Madhuca indica*), *neem* (*Azadirachta indica*), *pipal* (*Ficus religiosa*), *tendu* (*Diospyros melanoxylon*), *bugodi* (*Ardisia humilis*), *kevada* (*Pandanus tectorius*)

Soils

The soils in different landforms are of four orders: Entisols, Inceptisols, Alfisols and Vertisols. Inceptisols are the predominant soils, covering 42% of the area, followed by Entisols (37%), Alfisols (17%) and Vertisols (<1%). These soil orders are further categoried into 10 suborders, 17 great groups and 32 subgroups (Haldar *et al.*, 1996).

Land Use

About 63% of the area of the state is under cultivation, and nearly 72% of this is the net sown area. Forests account for nearly 17% of the state. The

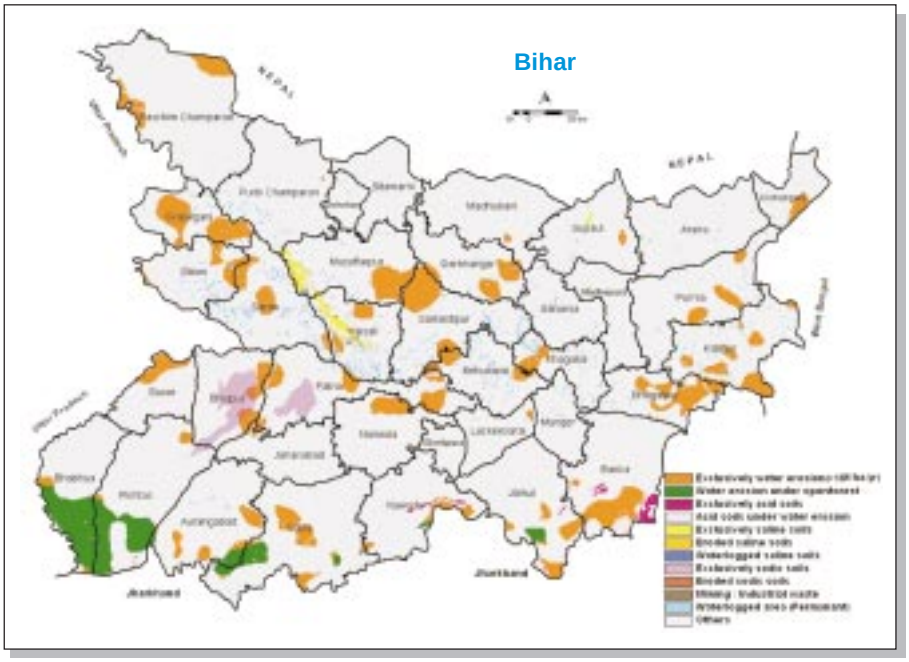

Fig. 26. Degraded and wastelands of Bihar
Source: NBSS&LUP

Table 27. Degraded and wastelands statistics of Bihar (Area in '000 ha)

Districts (37)	Degraded and wastelands classes*												Others**	Total
	1	2	3	4	7	8	12	13	14	18	19	Total of classes		
Araira	0	0	0	0	0	0	0	0	0	0	2	2	282	284
Aurangabad (B)	29	13	0	0	0	0	0	0	0	0	1	43	287	330
Banka	43	0	14	14	0	0	0	0	0	0	1	72	236	308
Behusarai	20	0	0	0	0	0	0	0	0	0	10	30	162	192
Bhabhua	8	106	0	0	0	0	0	0	0	0	0	114	217	331
Bhagalpur	71	0	0	0	0	0	0	0	0	0	2	73	184	257
Bhojpur	22	0	0	0	0	0	0	63	8	0	0	93	153	246
Buxar	22	0	0	0	0	0	0	0	0	0	1	23	140	163
Darbhanga	34	0	0	0	0	0	0	0	0	0	3	37	192	229
Gaya	45	29	0	0	0	0	0	0	0	0	0	74	422	496
Gopalganj	74	0	0	0	0	0	0	0	0	0	3	77	126	203
Jahanabad	3	0	0	0	0	0	0	0	0	0	0	3	154	157
Jamui	29	8	1	5	0	0	0	0	0	0	0	43	268	311
Katihar	50	0	0	0	0	0	0	0	0	0	9	59	247	306
Khagaria	15	0	0	0	0	0	0	0	0	0	9	24	125	149
Kishanganj	18	0	0	0	0	0	0	0	0	0	2	20	168	188
Luckeesarai	2	0	0	0	0	0	0	0	0	0	0	2	121	123
Madhepura	0	0	0	0	1	0	0	0	0	0	1	2	177	179
Madhubani	3	0	0	0	0	0	0	0	0	0	1	4	347	351
Munger	0	0	0	0	0	0	0	0	0	0	2	2	140	142
Muzaffarpur	42	0	0	0	17	0	2	0	0	0	6	67	248	315
Nalanda	22	0	0	0	0	0	0	0	0	0	0	22	213	235
Nawada	12	2	4	3	0	0	0	0	0	0	0	21	230	251
Paschim Champaran	42	1	0	0	0	0	0	0	0	0	0	43	480	523
Patna	49	0	0	0	0	0	0	31	0	0	3	83	236	319
Purbi Champaran	1	0	0	0	1	0	0	0	0	0	5	7	391	398
Purnia	26	0	0	0	0	0	0	0	0	0	4	30	293	323
Rohtas	6	70	0	0	0	0	0	4	0	1	0	81	301	382
Saharsa	0	0	0	0	0	0	0	0	0	0	5	5	165	170
Samastipur	54	0	0	0	0	0	0	0	0	0	13	67	223	290
Saran	31	0	0	0	1	0	0	0	0	0	18	50	215	265
Sheikpura	0	0	0	0	0	0	0	0	0	0	0	0	69	69
Sheohar	0	0	0	0	0	0	0	0	0	0	0	0	44	44
Sitamarhi	0	0	0	0	0	0	0	0	0	0	0	0	220	220
Siwan	26	0	0	0	0	0	0	0	0	0	10	36	187	223
Supaul	3	0	0	0	2	0	0	0	0	0	1	6	235	241
Vaisali	18	0	0	0	17	1	3	0	0	1	16	56	147	203
Total	820	229	19	22	39	1	5	98	8	2	128	1371	8,045	9,416

Notes: Classes*: **1** Exclusively water erosion (>10 tonnes/ha/yr); **2** Water erosion under open forest; **3** Exclusively acid soils; **4** Acid soils under water erosion; **7** Exclusively saline soils; **8** Eroded saline soils; **12** Water logged saline soils; **13** Exclusively sodic soils; **14** Eroded sodic soils; **18** Mining/Industrial waste; **19** Waterlogged area (Permanent)
Others**: Normal agricultural lands, water-bodies, rivers, lakes and habitats etc. (based on the limited reconnaisance survey)

Source: NBSS&LUP

remaining 20% is either left barren or is unculturable/culturable wasteland (Prasad, 1994).

Cereals, pulses, oilseeds, millets, fibre crops, vegetables, fruits and spices are the prevailing crops in the state. Basic system of cropping is cereal-based, and paddy, maize and wheat are the predominant crops.

In the alluvial plains in rainfed areas, paddy, maize, millets, pigeonpea, lentil, peas, chickpea, mungbean, mustard, rapeseed, castor, sugarcane, chillies, jute, mesta and sweet-potato are grown extensively. And in the irrigated areas, rice-wheat or rice-rice constitutes the most important crop rotations.

In the Chhotanagpur plateau, paddy is a predominant crop both in uplands and lowlands. Other crops grown are maize, wheat, millets, oilseed and pulses; and vegetables are grown where irrigation facilities are available.

Degraded and Wastelands

Degraded and wastelands in Bihar account for 1,371 thousand ha (14.5% of TGA) (Fig.26; Table 27)

Water erosion accounts for 11% (about 1,049 thousand ha) of the total area of the state. The worst affected districts are Bhabhua (114 thousand ha), Rohtas (76 thousan ha), Gaya (74 thousand ha), Bhagalpur (71 thousand ha), Samastipur (54 thousand ha) and Patna (49 thousand ha).

Acidic soils occupy about 41 thousand ha in Bihar; Banka district ranks highest in area (28 thousand ha), followed by Nawada (7 thousand ha) and Jamui (6 thousand ha).

Sodic soils are a major problem in Bhojpur (71 thousand ha) and Patna (31 thousand ha). And saline soils account for 45 thousand ha: 20 thousand ha in Vaishali and 19 thousand ha in Muzaffarpur.

Jharkhand

Location

Jharkhand is situated between 22°00 to 25°22 N latitudes and 83°21 to 87°58 E longitudes and is spread over 7.97 M ha (79,714 km^2). It is bounded by Bihar in the north, West Bengal in the north-east and east, Orissa in the south-east and south and Chhattisgarh and Uttar Pradesh in the west.

Physiography

Jharkhand landscape can be broadly divided into Bengal plains, Eastern plateau and Central highlands. The eastward extension of Indo-Gangetic alluvial plain covers eastern part of Sahebganj district and a small tract of Singhbhum, constituting western part of Bengal plains. The Eastern (Chhotanagpur) plateau

covers the major part of the southern hilly region, and the Central highlands cover north-western part of the state.

Geology

The important formations found are Archean, Vindhyas, Gondwana and Laterites. Archean rocks comprise granites and gneisses, and are partly Dharwarian rocks. Gondwana rocks are distributed in the east-west belt, parallel to the general structural trend of the Archean formations. Laterites are found as capping of plateau surfaces in the western Ranchi and Palamau districts.

Climate

It is subhumid, sub-tropical monsoonic type. The average annual rainfall of the state ranges from 1,000 and 2,000 mm. The mean summer temperature ranges from 29° to 32°C and mean winter temperature is between 17° and 19°C.

Natural Vegetation

The natural vegetation is tropical, moist deciduous. It covers hills of south Bihar and Chhotanagpur plateau. Major species found growing are: *babul* (*Acacia nilotica*), *bel* (*Aegle marmelos*), *ber* (*Zizyphus jujuba*), *behara* (*Terminalia*

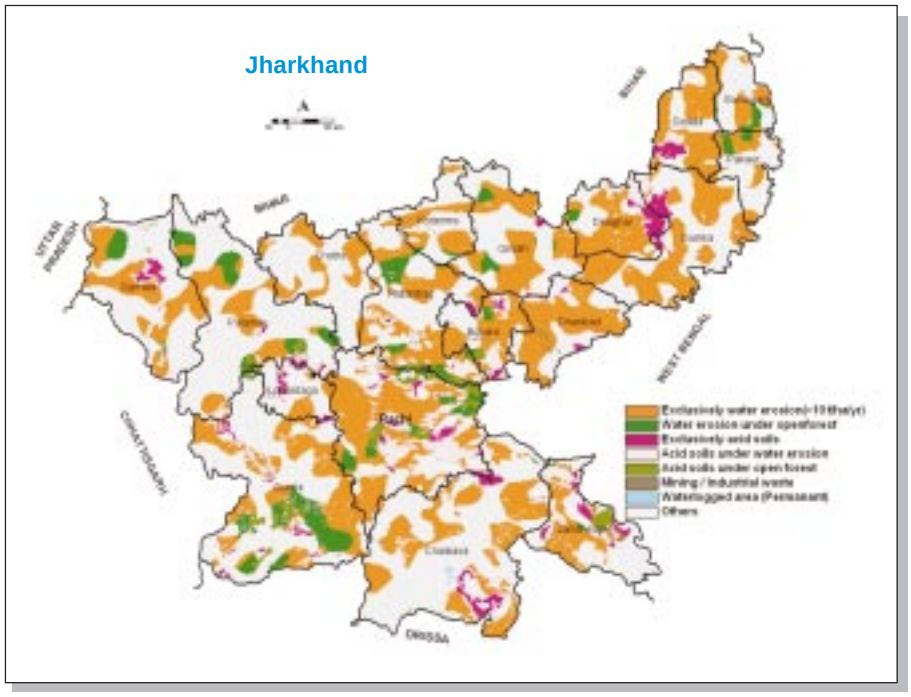

Fig. 27. Degraded and wastelands of Jharkhand
Source: NBSS&LUP

Table 28. Degraded and wastelands statistics of Jharkhand (Area in '000 ha)

Districts (18)	Degraded and wastelands classes*								Others**	Total
	1	2	3	4	5	18	19	Total of classes		
Bokaro	140	9	12	27	6	6	0	200	88	288
West Singhbhum	297	1	34	30	0	1	4	367	625	992
Chatra	102	3	0	0	0	0	0	105	265	370
Deoghar	130	5	23	25	0	0	0	183	67	250
Dhanbad	123	0	3	5	0	5	0	136	71	207
Dumka	305	0	25	26	0	0	0	356	269	625
Garhwa	123	17	13	9	1	1	0	164	240	404
Giridih	208	24	4	5	0	0	0	241	258	499
Godda	128	0	15	7	0	0	0	150	63	213
Gumla	260	91	19	22	25	0	0	417	487	904
Hazaribag	229	51	6	52	18	2	0	358	255	613
East Singhbhum	95	4	24	37	17	0	1	178	174	352
Koderma	48	4	0	0	0	1	0	53	79	132
Lohardaga	31	1	11	5	2	1	0	51	98	149
Pakaur	52	14	0	0	0	0	1	67	113	180
Palamau	166	75	7	22	11	1	0	282	584	866
Ranchi	335	44	30	122	35	3	0	569	199	768
Sahibganj	53	13	0	0	0	0	0	66	93	159
Total	2,825	356	226	394	115	21	6	3,943	4,028	7,971

Notes: Classes*:**1** Exclusively water erosion (>10 tonnes/ha/yr); **2** Water erosion under open forest; **3** Exclusively acid soils; **4** Acid soils under water erosion; **5** Acid soils under open forest; **18** Mining/Industrial waste; **19** Waterlogged area (Permanent)
Others**: Normal agricultural lands, water-bodies, rivers, lakes and habitats etc. (based on the limited reconnaisance survey)
Source: NBSS&LUP

belerica), *imli* (*Tamarindus indica*), *jamun* (*Syzigium cumini*), *khair* (*Acacia catechu*), *khajur* (*Phoenix sylvestris*), *mahua* (*Madhuca indica*), *neem* (*Azadirachta indica*), *pipal* (*Ficus religiosa*), *tendu* (*Diospyros melanoxylon*) and *bugodi* (*Ardisia humilis*).

Soils

Major soils are Alfisols (46% of TGA), followed by Inceptisols (28%) and Entisols (28%) (Sahoo *et al.,* 2005). Major great groups are Ochraqualfs, Plinthaqualfs, Haplustalfs, Rhodustalfs, Haplaquepts, Ustochrepts, Eutrochrepts, Fluvaquents, Ustipsamments, Ustifluvents and Ustorthents.

Land Use

In Chhotanagpur plateau, paddy is the predominant crop under upland and lowland situations. Other crops grown are maize, wheat, millets, oilseeds and pulses, and vegetables are grown only with irrigation facilities.

Agricultural productivity of the state is rather low because traditional methods of cultivation and local varieties of crops are being mostly used by the

small and marginal farmers. Lac production is popular household proposition as a cash crop. Silk rearing on the mulberry is also practised.

Degraded and Wastelands

Total degraded lands in the state are spread over 3,943 thousand ha, which is about 49% of TGA (Fig. 27; Table 28). Water erosion is very rampant and it is observed in 3,181 thousand ha (40% of TGA); Ranchi ranks first (379 thousand ha), followed by Gumla (351 thousand ha), Dumka (305 thousand ha), West Singhbhum (298 thousand ha) and Hazaribag (280 thousand ha) (Fig. 27, Table 28).

About 735 thousand ha (9% of TGA) of the state is affected by different classes of acid soils; highest is in Ranchi with 187 thousand ha, followed by East Singhbhum (78 thousand ha), Hazaribagh (76 thousand ha) and Gumla (66 thousand ha). Mining and industrial waste and waterlogged areas account for 21 thousand ha and 6 thousand ha.

Orissa

Location

Orissa covering 15.57 M ha (155,707 km^2) is situated between 17°47 to 22°33 N latitudes and 81°21 to 87°30 E longitudes. It is bounded by West Bengal in the north-east, Jharkhand in north, Andhra Pradesh in the south-east, Chhattisgarh in the west and Bay of Bengal in the east.

Physiography

The state has been demarcated into Northern plateau, Central tableland, Eastern Ghats and East coastal plains. Northern plateau is an extension of Chhotanagpur plateau. It consists of tablelands of different elevations bordered by steep escarpments with low rounded hills and mature valleys. The central tableland in the middle and west of the state between the northern uplands and hills of Eastern Ghats has an average elevation of more than 900 m above msl. Eastern Ghats consist of hill ranges covering 36% of the TGA of the state and lie to the east and south west of the central tableland. East coastal plains are developed by the delta of the Mahanadi river and lower courses of mature rivers, the Brahmani, the Baitarni, the Subarnarekha and the Rushikulya, forming broad valleys.

Geology

The formations comprise rocks from the Archaen to the Pleistocene age. The unclassified crystallines, which include granites, gneisses and other

magmatic rocks are found in the north-western and southern parts of the state. Precambrian formations group occurs mostly in Eastern Ghats. Large deposits of laterites occur as capping over Khondalite hills. Pleistocene alluvium occurs at several places along the coastal tract.

Climate

It is hot to sub-humid subtropical. The minimum and maximum temperatures during March to October in the highlands region range around 13.5° to 18.5°C and 31.3° to 34.5°C. In Dandakaranaya region, variation is from 12° to 19°C and 30° to 32°C, and in the coastal areas it is from 17° to 20°C and 32° to 35°C. And mean rainfall varies from 1,394 to 1,750 mm annually.

Natural Vegetation

Orissa has 58,130 km^2 of forest area (Statistical Abstract, Directorate of Economics and Statistics, Govt of Orissa, 2005). Forests types are tropical semi-evergreen forest, tropical moist deciduous forest, tropical dry deciduous forest and mangrove forests.

The common species found in the forest are: *babul* (*Acacia nilotica*), *bel* (*Aegle marmelos*), *ber* (*Zizyphus jujuba*), *behara* (*Terminalia belerica*), *imli* (*Tamarindus indica*), *jamun* (*syzygium cumini*), *khair* (*Acacia catechu*), *khajur* (*Phoenix sylvestris*), *mahua* (*Madhuca indica*), *neem* (*Azadirachta indica*), *pipal* (*Ficus religiosa*), *tendu* (*Diospyros melanoxylon*), *bugodi* (*Ardisia humilis*) and *kevada* (*Pandanus tectorius*)

Soils

They have been grouped into Entisols, Inceptisols, Alfisols and Vertisols. Inceptisols are the dominant soils, covering 49% area, followed by Alfisols (34%), Entisols (10%) and Vertisols (6%). These orders have been further categorized into 9 suborders, 15 great groups and 34 subgroups.

Major great groups found are: Ochraqualfs, Plinthustalfs, Kanhaplustalfs, Paleustalfs, Rhodustalfs, Fluvaquents, Ustipsamments, Ustorthents, Tropaquepts, Haplaquepts, Ustropepts, Ustochrepts and Chromusterts (Sarkar *et al.,* 1998).

Land Use

About 50% of the total area of the state is under cultivation. Forests cover 37% and lands not suitable for cultivation are 6%, and current fallows cover 3% area of the state. Paddy is the main food crop and is grown in 4,200 thousand ha. It constitutes about 61% of the total area under food crops. Other major food crops grown are: ragi, wheat, small millets and maize. The area under wheat

increased from 21 thousand ha in 1970–71 to 89 thousand ha in 1990–91, but the net area under paddy reduced from 4,600 thousand ha to 4,100 thousand ha during the same period.

Degraded and Wastelands

Total degraded lands in Orissa cover 3,722 thousand ha (24% of TGA); districts in order of severity of degradation are Koraput (412 thousand ha), Rayagada (334 thousand ha), Phulbani (330 thousand ha), Kalahandi (313 thousand ha) and Gajapati (305 thousand ha) (Fig. 28; Table 29).

Barring coastal districts, soil erosion has affected almost all parts of Orissa (21% of TGA). Koraput is worst affected (400 thousand ha), followed by Phulbani (330 thousand ha), Kalahandi (313 thousand ha), Gajapati (260 thousand ha) and Nowrangpur (196 thousand ha).

Soil acidity is found in the undulating and hilly parts; Gajapati (45 thousand ha), Ganjam (30 thousand ha), Malkangiri (29 thousand ha), Angul (20 thousand

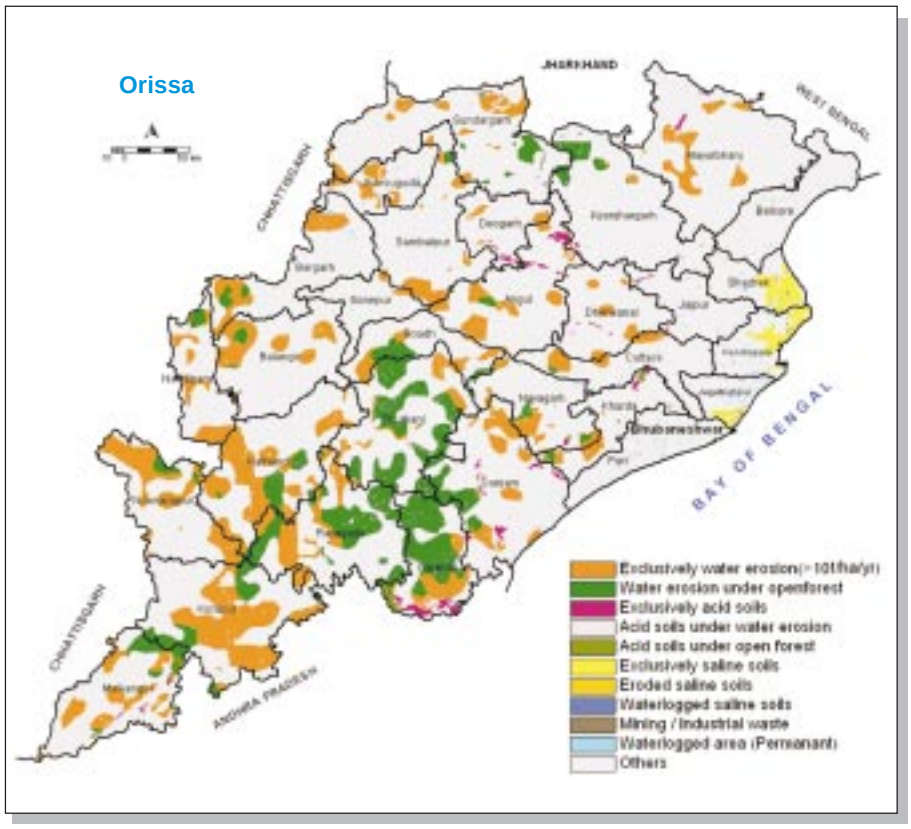

Fig. 28. Degraded and wastelands of Orissa
Source: NBSS&LUP

Table 29. Degraded and wastelands statistics of Orissa (Area in '000 ha)

Districts (30)	Degraded and wastelands classes*										Others**	Total
	1	2	3	4	5	7	12	18	19	Total of classes		
Angul	90	8	18	2	0	0	0	0	0	118	520	638
Balangir	113	14	0	0	0	0	0	0	0	127	530	657
Balasore	0	0	0	0	0	0	0	1	4	5	375	380
Bargarh	99	20	0	0	0	0	0	0	4	123	461	584
Bhadrak	0	0	0	0	0	62	2	0	4	68	175	243
Boudh	48	38	0	0	0	0	0	0	0	86	223	309
Cuttack	49	3	1	0	0	0	0	0	2	55	338	393
Deogarh	19	0	8	2	0	0	0	0	0	29	264	293
Dhenkanal	37	0	5	0	0	0	0	1	0	43	402	445
Gajapati	68	192	26	5	14	0	0	0	0	305	134	439
Ganjam	107	73	19	6	5	0	0	0	2	212	610	822
Jagatsinghpur	0	0	0	0	0	17	2	0	7	26	138	164
Jajpur	1	0	3	0	0	0	0	1	3	8	281	289
Jharsuguda	38	0	0	0	0	0	0	0	1	39	169	208
Kalahandi	252	61	0	0	0	0	0	0	0	313	482	795
Kendrapara	0	0	0	0	0	52	2	0	6	60	197	257
Keonjhargarh	7	47	4	2	2	0	0	2	2	66	763	829
Khurda	23	5	5	1	5	0	0	1	1	41	241	282
Koraput	316	84	0	11	1	0	0	0	0	412	474	886
Malkangiri	120	45	5	13	11	0	0	0	0	194	387	581
Mayurbhanj	97	0	8	2	0	0	0	0	1	108	932	1,040
Nawapara	83	15	0	0	0	0	0	0	0	98	286	384
Nayagarh	54	20	2	0	2	0	0	0	1	79	310	389
Nowrangpur	176	20	0	1	0	0	0	0	0	197	335	532
Phulbani	70	260	0	0	0	0	0	0	0	330	475	805
Puri	0	0	0	0	0	0	0	0	8	8	337	345
Rayagada	133	200	0	0	1	0	0	0	0	334	376	710
Sambalpur	69	6	0	0	0	0	0	0	0	75	589	664
Sonepur	11	0	0	0	0	0	0	0	0	11	222	233
Sundargarh	96	41	3	6	4	0	0	2	0	152	823	975
Total	2,176	1,152	107	51	45	131	6	8	46	3,722	11,849	15,571

Notes: Classes*: **1** Exclusively water erosion (>10 tonnes/ha/yr); **2** Water erosion under open forest; **3** Exclusively acid soils; **4** Acid soils under water erosion; **5** Acid soils under open forest; **7** Exclusively saline soils; **12** Waterlogged saline soils; **18** Mining/Industrial waste; **19** Waterlogged area (Permanent)
Others**: Normal agricultural lands, water-bodies, rivers, lakes and habitats etc. (based on the limited reconnaisance survey)
Source: NBSS&LUP

ha) and Deogarh (10 thousand ha) are prominent districts with acid soils.

Salinity is found in Bhadrak, Kendrapara and Jagatsinghpur districts. And waterlogging is mainly confined to the coastal areas and Puri (8 thousand ha), Jagatsinghpur (7 thousand ha), Kendrapara (6 thousand ha), Bargarh, Bhadrak and Balasore (4 thousand ha each) are prominent districts.

Mining for iron ore, manganese and other valuable minerals has rendered many areas wastelands; Keonjhargarh and Sundargarh (2 thousand ha each), followed by Balasore, Dhenkanal, Khurda and Jajpur (1 thousand ha each).

West Bengal

Location

West Bengal covers 8.87 M ha (88,752 km^2) and is situated between 21°30′ to 27°14′N latitudes and 85°51′ to 89°52′E longitudes. It is bounded by Sikkim and Bhutan in the north; Orissa in south-west; Bihar and Nepal in the west and Asom in the north-east.

Physiography

West Bengal is divided into Eastern Himalayas (in the north), Eastern plateau or Chhotanagpur plateau (in the west and south-west) and Alluvial and Deltaic plains (in the east and south).

The Eastern Himalayas include mountainous terrain of Darjeeling and northern fringe of Jalpaiguri, comprising foothills of Bhutan Himalayas. The inner terrain of Darjeeling Himalayas, extends to Sikkim and Nepal.

The Eastern plateau comprising Peninsular mass is known as Chhotanagpur plateau. Eastward section extends across the north-western parts of Barddhaman, Medinipur, Bankura, Birbhum and whole of Purulia. The subdued spurs of laterite formation are frequently observed in western part of Bankura, part of Medinipur and Purulia.

The extensive stretch of Alluvial and Deltaic plains in the east and south of the state are called as Bengal Basin, comprising eastward extension of Indo-Gangetic alluvial plain.

Geology

The formations comprise Archaen, metamorphics to sub-recent and recent alluvium formations. About 75% of the landmass comprises sub-recent to recent alluvial deposits and the remaining abounds in a wide variety of rock formations like crystallines, sedimentaries and basic flows.

Climate

In the state, minimum temperature is around 0°C in winter in the hilly regions of the north. The temperature rises to as high as 46°C during summer in the lateritic region of the south-west. The average annual rainfall varies between 1,100 and 3,500 mm.

Natural Vegetation

Natural vegetation is temperate forest in the Eastern Himalayas, tropical forest in Dooars, dry/moist deciduous forest in the plateau outliers, and mangrove forest in the Sundarbans (Southern delta).

Species found in the forest are: *babul* (*Acacia nilotica*), *bel* (*Aegle marmelos*), *ber* (*Zizyphus jujuba*), *behara* (*Terminalia belerica*), *imli* (*Tamarindus indica*), *jamun* (*Syzygium cumini*), *khair* (*Acacia catechu*), *khajur* (*Phoenix sylvestris*), *mahua* (*Madhuca indica*), *neem* (*Azadirachta indica*), *pipal* (*Ficus religiosa*), *tendu* (*Diospyros melanoxylon*), *bugodi* (*Ardisia humilis*), *kevada* (*Pandanus tectorius*). The mangrove forests in the Sundarbans comprise *sunderi* (*Heritiera macrophylla*) (the name Sundarbans is given due to this plant species).

Soils

They belong to 3 orders, 10 suborders, 19 great groups and 36 subgroups. Inceptisols are predominant soils, followed by Alfisols and Entisols, occupying 52%, 23% and 22% of the total geographical area of the state. The soil great

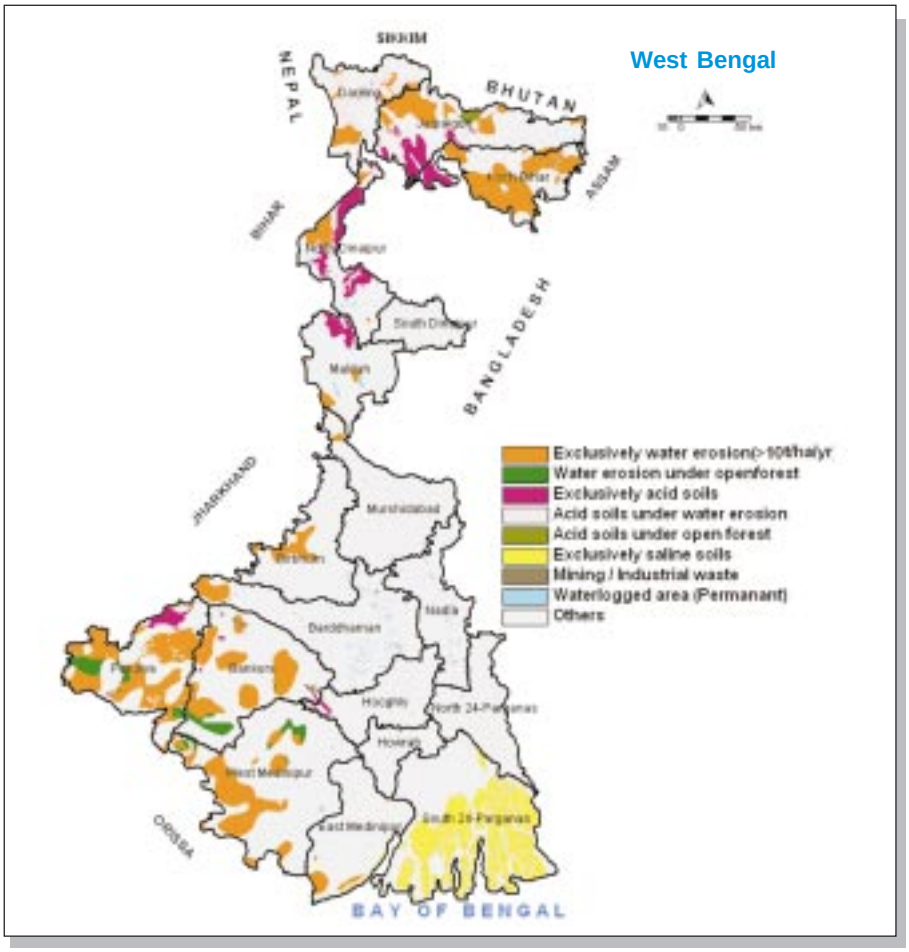

Fig. 29. Degraded and wastelands of West Bengal
Source: NBSS&LUP

Table 30. Degraded and wastelands statistics of West Bengal (Area in '000 ha)

Districts (19)	Degraded and wastelands classes*									Others**	Total
	1	2	3	4	5	7	18	19	Total of classes		
Bankura	169	30	6	0	2	0	4	0	211	482	693
Barddhaman	34	0	0	0	0	0	1	13	48	654	702
Birbhum	47	0	0	7	0	0	0	1	55	401	456
Darjeeling	44	0	3	93	0	0	0	0	140	178	318
East Medinipur	27	0	0	0	0	7	0	2	36	442	478
Hugali	0	0	8	0	0	0	0	1	9	305	314
Haora	0	0	0	0	0	0	0	1	1	146	147
Jalpaiguri	130	2	69	39	10	0	0	3	253	374	627
Koch Bihar	174	0	22	1	0	0	0	4	201	143	344
Kolkata	0	0	0	0	0	0	0	0	0	19	19
Maldah	16	0	27	0	0	0	0	4	47	326	373
Murshidabad	6	0	0	0	0	0	0	1	7	524	531
Nadia	0	0	0	0	0	0	0	6	6	386	392
North 24-Parganas	0	0	0	0	0	0	0	0	0	408	408
North Dinajpur	39	0	74	13	0	0	0	5	131	186	317
Puruliya	285	43	28	11	1	0	2	1	371	263	634
South 24-Parganas	0	0	0	0	0	401	0	0	401	567	968
South Dinajpur	0	0	0	0	0	0	0	0	0	221	221
West Medinipur	196	22	3	1	0	0	0	1	223	710	933
Total	1,167	97	240	165	13	408	7	43	2,140	6735	8,875

Notes: Classes*: **1** Exclusively water erosion (>10 tonnes/ha/yr); **2** Water erosion under open forest; **3** Exclusively acid soils; **4** Acid soils under water erosion; **5** Acid soils under open forest; **7** Exclusively saline soils; **18** Mining/Industrial waste; **19** Waterlogged area (Permanent)
Others**: Normal agricultural lands, water-bodies, rivers, lakes and habitats etc. (based on the limited reconnaisance survey)
Source: NBSS&LUP

groups present are: Ochraqualfs, Paleustalfs, Haplustalfs, Rhodustalfs, Hapludalfs, Haplaquepts, Ustochrepts, Eutrochrepts, Dystrochrepts, Fluvaquents, Udipsamments, Udorthents and Ustorthents (Haldar *et al.,* 1992).

Land Use

In the densely populated West Bengal, there is heavy pressure on the meagre land resources. About 75% of the population has per capita holding of around 0.16 ha.

About 60% of the total area of the state is under cultivation and 24% of the cultivated land comprising 1.28 M ha is under irrigation. Forest lands account for 12% and lands not available for cultivation account for 18% of the total geographical area of the state. Paddy is the main crop and rice-rice-vegetable, jute-rice-vegetable and rice-wheat are very prominent cropping systems. Dooars and Darjeeling are famous for tea and oranges. However, drought-prone areas like Puruliya, Bankura, part of Bribhum and West Medinipur grow a single crop of paddy.

Degraded and Wastelands

Out of 8,875 thousand ha of the state, 2,140 thousand ha (24% of TGA) are affected by various kinds of degradations. About 14% of the area is affected by water erosion, of which Puruliya is affected to the extent of 328 thousand ha, followed by West Medinipur (218 thousand ha), Bankura (199 thousand ha), Koch Bihar (174 thousand ha) and Jalpaiguri (132 thousand ha) (Fig. 29; Table 30).

The second major cause of land degradation is soil acidity. Acidic soils cover 418 thousand ha (5% of TGA); of which 165 thousand ha is also associated with water erosion. Jalpaiguri district has highest coverage of acid soils (118 thousand ha), followed by Darjeeling (96 thousand ha), North Dinajpur (87 thousand ha) and Puruliya (40 thousand ha). Saline soils cover 408 thousand ha, mostly in South 24 Parganas. Waterlogging is observed in Barddhaman, Nadia, North Dinajpur and Maldah and Koch Bihar and mining wastelands are confined to Bankura and Puruliya.

CENTRAL REGION

The central region comprises Chhattisgarh, Madhya Pradesh and Maharashtra.

Chhattisgarh

Location

The state has a total geographical area of 13.48 M ha (134,805 km^2), constituting 4% of the total geographical area of the country. Chhattisgarh is situated between 17°46′ to 24°6′ N latitudes and 80°15′ to 84°51′ E longitudes. It is bounded by hilly region and plains and is surrounded by Uttar Pradesh in the north and Jharkhand in the north-east, Orissa in east, Andhra Pradesh in the south-west, Maharashtra and Madhya Pradesh in the west.

Physiography

The state is divided into Eastern Baghelkhand plateau (sedimentary), Eastern Baghelkhand Plateau (basalt), Eastern Plateau Mahanadi basin (sedimentary), Eastern Dandakaranya plateau (Granite/gneissic), Eastern Dandakaranya plateau (sedimentary), Eastern Dandakaranya plateau (laterite), Eastern Dandakaranya plateau (basalt), Eastern Chhotanagpur plateau (granitic-laterite), Eastern Chhotanagpur plateau (sedimentary-Dharwar), Eastern Chhotanagpur plateau (basaltic-laterite).

Geology

The major formations are made up of basalt, granite, sandstone, laterite and their alluvium.

Climate

It is mainly tropical, hot sub-humid dry/moist. The state lies at an elevation ranging from 300 to 600 m above mean sea level. It receives rainfall mainly through south-west monsoon, which varies from 1,200 mm in the north-west to 2,000 mm in the south-east with an average of 1,400 mm distributed over 64 rainy days. Highest annual rainfall of 1,640 mm is received in Raigarh district in 73 days. The lowest annual rainfall of 1,215 mm is received in 64 rainy days in Rajanandgaon district.

May is the hottest month (46°C) and December–January is the coldest (7°C).

Natural Vegetation

The forests in the state occupy 6.52 M ha (44%) of the total geographical area. It is famous in the entire country for its *sal* forests. In addition, teak, bamboo, *saja*, *sarai* also have larger coverage, besides following species are also found growing in the state: *jamun* (*Syzygium cumini*). *pisa* (*Actinodaphne angustifolia*), *anjani* (*Memecylon umbellatum*), *hirda* (*Terminalia chebula*), teak (*Tectona grandis*), *arjun* (*Terminalia arjuna*), *haldu* (*Adina cordifolia*). *Tiwas* (*Ougeinia dalbergioides*), *khair* (*Acacia catechu*), *shivan* (*Gmelina arborea*), *dhavada* (*Anogeissus latifolia*), *salai* (*Baswellia serrata*), *palas* (*Butea monosperma*), *babul* (*Acacia nilotica*) and *ber* (*Zizyphus jujuba*). *Tendu* leaf, which is used in *beedi*-making, is a principal forest by-product. There are large number of other minor forest products too.

Soils

They are categorized into following orders: Entisols (10%), Inceptisols (34%), Alfisols (35%), Vertisols (20%), Mollisols (>1%) and rock outcrop (>1%). And these orders are further categorized into 6 suborders, 10 great groups and 22 subgroups. Some of the prominent great groups are: Ustorthents, Haplustepts, Haplustolls, Haplusterts, Haplustalfs, Rhodustalfs, Plinthustalfs, Plinthaqualfs and Ochraqualfs (Tamgadge *et al.,* 2003).

Land Use

Principally, paddy is the main crop grown in *kharif* covering 3,700 thousand ha; constituting 77% of net sown area; Raipur district has the highest area (500 thousand ha), followed by Bilaspur (300 thousand ha) and Rajnandgaon (200 thousand ha). Bastar (200 thousand ha), Surguja (300 thousand ha), Jashpur (200

thousand ha) and Koria (68 thousand ha). The net sown area varies from 18.6% in Koria to 63% in Durg. Double cropped area is higher in Durg (200 thousand ha), followed by Bilaspur (100 thousand ha) and Raipur (100 thousand ha). However, percentage of net sown area is highest in Durg district (21%), followed by Dhamtari (16%), Bilaspur (13%), Kawardha (11%), Rajnandgaon (10%) and Raipur (7%).

State has a cropping intensity of 121%. The other crops grown are kodo-kutaki (about 100 thousand ha), maize (24 to 45 thousand ha) and soybean (100 thousand ha). *Rabi* crops are lathyrus chickpea, wheat and linseed.

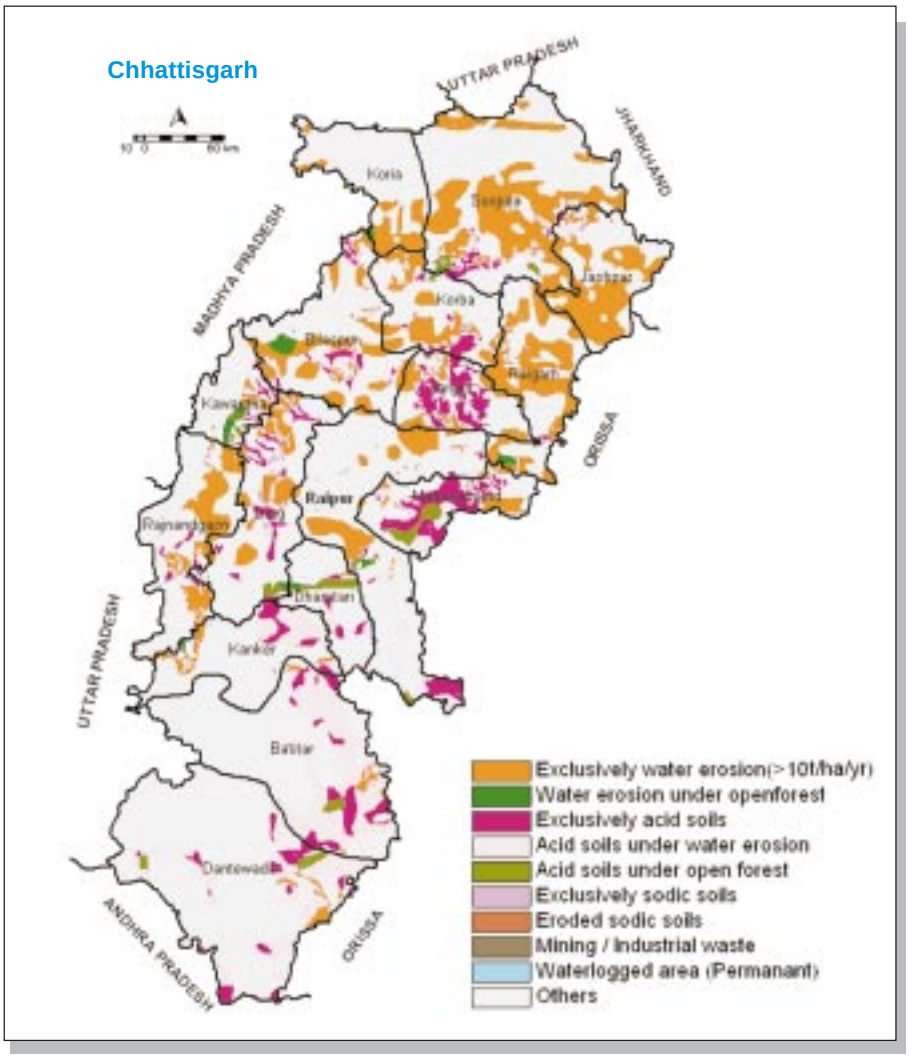

Fig. 30. Degraded and wastelands of Chhattisgarh
Source: NBSS&LUP

Table 31. Degraded and wastelands statistics of Chhattisgarh (Area in '000 ha)

Districts (19)	Degraded and wastelands classes*										Others**	Total
	1	2	3	4	5	13	14	18	19	Total of classes		
Bastar	21	0	119	451	12	0	0	0	0	603	897	1,500
Bilaspur	181	22	39	46	0	0	0	0	0	288	535	823
Dantewada	28	1	79	272	20	0	0	0	0	400	1356	1,756
Dhamtari	2	5	18	71	22	0	0	0	0	118	220	338
Durg	137	3	78	38	11	10	3	2	0	282	572	854
Janjgir	73	0	114	25	1	0	0	1	0	214	176	390
Jashpur	282	0	3	32	0	0	0	0	0	317	264	581
Kanker	28	3	47	126	1	0	0	0	0	205	445	650
Kawardha	32	22	24	18	13	0	0	0	0	109	311	420
Korba	182	0	45	50	3	0	0	1	0	281	378	659
Koria	124	3	0	0	0	0	0	0	0	127	526	653
Mahasamund	47	0	140	61	36	0	0	0	0	284	203	487
Raigarh	320	9	4	25	1	0	0	0	0	359	345	704
Raipur	158	4	49	81	12	0	0	3	0	307	993	1,300
Rajnandgaon	201	1	20	29	0	0	0	0	0	251	550	801
Surguja	531	2	33	58	15	0	0	0	0	639	926	1,565
Total	2,347	75	812	1383	147	10	3	7	0	4,784	8,697	13,481

Notes: Classes*: **1** Exclusively water erosion (>10 tonnes/ha/yr); **2** Water erosion under open forest; **3** Exclusively acid soils; **4** Acid soils under water erosion; **5** Acid soils under open forest; **13** Exclusively sodic soils; **14** Eroded sodic soils; **18** Mining/Industrial waste; **19** Waterlogged area (Permanent)
Others**: Normal agricultural lands, water-bodies, rivers, lakes and habitats etc. (based on the limited reconnaisance survey)
Source: NBSS&LUP

Degraded and Wastelands

Chhattisgarh has 4,784 thousand ha (about 35% of the TGA) affected by different kinds of degradations. The degraded area is 639 thousand ha in Surguja, 603 thousand ha in Bastar, 400 thousand ha in Dantewada, 359 thousand ha in Raigarh, 317 thousand ha in Jashpur and 307 thousand ha in Raipur (Fig. 30; Table 31).

Major area is affected by water erosion, totalling to 2,422 thousand ha (18% of TGA). Water erosion is 533 thousand ha in Surguja, 329 thousand ha in Raigarh and 282 thousand ha in Jashpur, 202 thousand ha in Rajnandgaon and 203 thousand ha in Bilaspur. Other badly affected districts are Durg, Raipur, Korba and Koria. Soil erosion in open forest area accounts for 75 thousand ha, most prominently in Bilaspur and Kawardha districts.

Soil acidity second major factor of land degradation is in 2,342 thousand ha (17% of TGA). Districts affected by acidity are Bastar (582 thousand ha), Dantewada (371 thousand ha), Mahasamund (237 thousand ha), Kanker (174 thousand ha), Raipur (142 thousand ha) and Durg (127 thousand ha). About 7 thousand ha has been degraded to wastelands in Raipur, Durg and Janjgir due to mining.

Madhya Pradesh

Location

It is located between 18°05′ to 26°01′ N latitudes and 72°05′ to 84°30′ E longitudes, covering 44.34 M ha (308,641 km^2), which is 13.5% of the TGA of the country. It is bounded by Rajasthan and Gujarat in the north-west, Bihar and Orissa in East, Andhra Pradesh in south and Maharashtra in south-west.

Physiography

Depending upon the elevation, slope and ruggedness of terrain, the state has been divided into North Deccan plateau, Central highlands, and Eastern plateau and Transects.

Deccan plateau mainly consists of Satpura range of hills and occupies extreme southern part of the state, adjoining Maharashtra. Satpura range is considerably dissected, and its ridges and furrows are relief features of granite and basalt (Cambrian) mountain system, subjected to prolonged denudation chronology.

Central highlands have been divided into Narmada valley, Vindhyan ranges, Malwa plateau, Pathar and Bundelkhand upland. It is the central part of the state called Central peninsular of India.

Eastern plateau and Transects consist of Baghelkhand plateau, Mahanadi basin, Dandakaranya plateau and Chhotanagpur plateau. The Eastern plateau comprises Chhattisgarh basin and Bastar district.

Madhya Pradesh has varied topography, ranging from levelled land to hills of different elevations. Eroded land surfaces and river valleys are found between them. The Satpura, Vindhyachal and Maikal are the main mountains. The important plateaux of the state are: Malwa, Bundelkhand (Central India), Rewa-Panna (Baghelkhand), Sagar and Damoh.

Geology

The geological formations comprise Archaean, metamorphic to sub-recent and recent alluvium formations. Metamorphic formations include schists, gneiss of Precambrian age associated with basic and acidic intrusives. Sedimentaries include essentially of Gondwana, Vindhyan and Dharwar formations. Deccan plateau is associated with granite, basalt, sandstone and laterites. The central highlands are mainly associated with basalt, granite, sandstone, quartzite and alluvium. Eastern plateau is composed of granite and sandstone.

Climate

It has a wide variation in climate, ranging from semi-arid (dry moist to

moist), sub-humid to humid tropical. The mean annual rainfall varies from 500 to 3,500 mm. It is received during June to September. Rainfall in the Central part of the state (Mandla and Ambikapur) ranges from 1,200 to 1,600 mm and in the eastern, northern and western regions, it is about 1,600 mm.

The mean annual temperature ranges from 22.5° to 27.5°C with the summer temperature from 25° to 35°C, rainy season temperature from 25° to 30°C, and winter temperature from 17.5° to 25°C.

Natural Vegetation

Madhya Pradesh forests are of deciduous and thorny nature, covering about 32% of the area in the state. Due to climatic and topographic variations, there are three dominant forest belts. Based on ecology, the whole forest belt has been classified into: tropical evergreen forest, tropical moist deciduous forest, tropical dry deciduous forest and tropical thorny forest.

The plant species found are *babul* (*Acacia nilotica*), *bel* (*Aegle marmelos*), *ber* (*Zizyphus jujuba*), *behara* (*Terminalia belerica*), *imli* (*Tamarindus indica*), *jamun* (*Syzygium cumini*), *khair* (*Acacia catechu*), *khajur* (*Phoenix sylvestris*), *mahua* (*Madhuca indica*), *neem* (*Azadirachta indica*), *pipal* (*Ficus religiosa*), *tendu* (*Diospyros melanoxylon*) and *bugodi* (*Ardisia humilis*).

Soils

They have been classified in 5 orders, 7 suborders, 11 great groups, 26 subgroups and 130 families. The Inceptisols are predominant, covering 48%; followed by Entisols and Alfisols 10% each, Vertisols 21% and Mollisols <1% of the total geographical area of the state (Tamgadge *et al.,* 1996).

Land Use

About 54% area is under cultivation, of which about 22% is under double cropping and 32% is under forests. The remaining about 15% is left barren (uncultivable and cultivable wastelands). Of the cultivated area, about 10% is under irrigation. The main crops are paddy, wheat, sorghum, chickpea, pigeonpea, cotton, soybean, maize, pearl millet, groundnut, sugarcane, sesamum, linseed, niger, blackgram, poppy and fruits and vegetables.

Of the total cropped area (22.40 M ha), the food crops (cereals and pulses) occupy 15.5 M ha. The dominant cereals are wheat, sorghum, maize, and minor millets. The important pulses grown are chickpea, blackgram and pigeonpea, and oilseed crops are linseed, groundnut, sesamum, rapeseed and mustard. Area under soybean (1,000 thousand ha) is increasing fast. Among individual crops, paddy occupies largest area (5,000 thousand ha; 22%), followed by wheat (3,600 thousand ha; 16%) and then sorghum (1,000 thousand ha; 8%).

The eastern part is mostly under paddy, minor millets, wheat, chickpea and vegetables. Western part is dominated by minor millets, cotton, sorghum, paddy, wheat, chickpea, mustard, madia and poppy. Northern part usually grows mustard, paddy, wheat, chickpea, sugarcane and vegetables, and southern part normally cultivates paddy, minor millets, wheat, chickpea, oilseeds and vegetables. The central part is mainly under soybean, wheat, chickpea, paddy, pulses, sugarcane, potato and vegetables.

Degraded and Wastelands

The state has 14,095 thousand ha of degraded and wastelands, about 23% of the state's geographical area. Districts with large areas of degraded lands are Khargone (785 thousand ha), Chhindwara (648 thousand ha), Dhar (643 thousand ha), Khandwa (581 thousand ha), Mandsaur (525 thousand ha) and Shahdol (508 thousand ha) (Fig. 31; Table 32).

The total area affected by water erosion (including open forest areas) accounts for 13,465 thousand ha (44% of TGA). Worst affected districts are Khargone (779 thousand ha), Dhar (638 tholusand ha), Chhindwara (588 thousand ha) and Shivpuri (488 thousand ha). Some districts have areas ranging from 200 to 400 thousand ha under degraded lands. Ujjain, Balaghat, Bhinda, Bhopal,

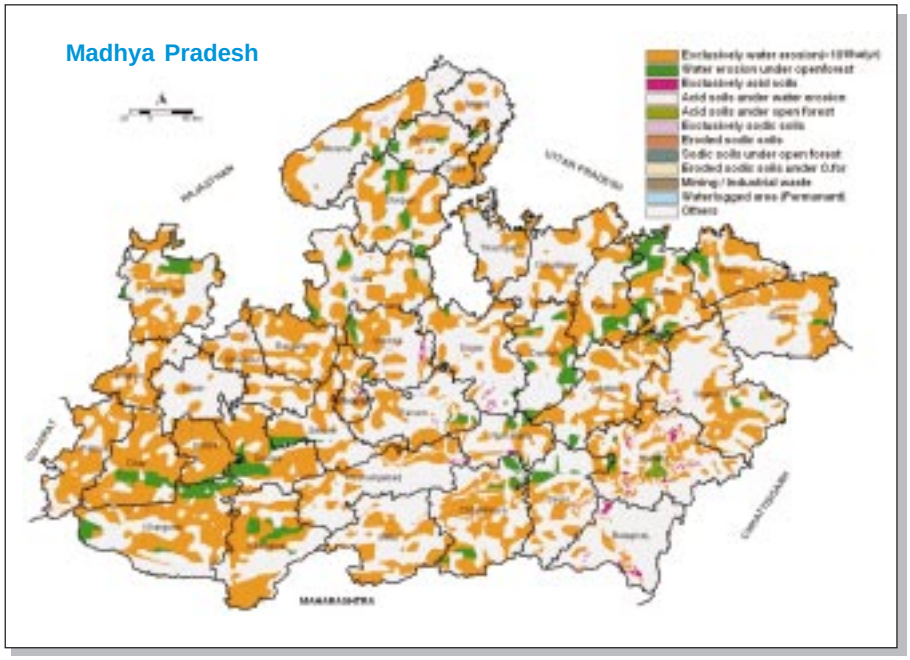

Fig. 31. Degraded and wastelands of Madhya Pradesh
Source: NBSS&LUP

Table 32. Degraded and wastelands statistics of Madhya Pradesh (Area in '000 ha)

Districts (38)	Degraded and wastelands classes*												Others**	Total
	1	2	3	4	5	13	14	16	17	18	19	Total of classes		
Balaghat	66	0	30	53	0	0	0	0	0	2	0	151	768	919
Betul	345	2	0	8	0	0	0	0	0	1	0	356	648	1,004
Bhind	114	0	0	0	0	6	6	0	0	0	0	126	319	445
Bhopal	145	2	4	5	1	2	5	0	0	0	0	164	115	279
Chhatarpur	297	0	0	0	0	0	0	0	0	0	0	297	571	868
Chhindwara	504	84	2	55	1	0	0	0	0	2	0	648	537	1,185
Damoh	169	125	0	0	0	0	0	0	0	1	0	295	435	730
Datia	123	12	0	0	0	0	4	0	0	0	0	139	130	269
Dewas	400	91	0	0	0	1	1	0	0	0	0	493	213	706
Dhar	555	83	1	4	0	0	0	0	0	0	0	643	178	821
Guna	415	67	0	1	0	0	0	0	0	0	0	483	625	1,108
Gwalior	113	41	0	0	0	13	1	0	0	0	0	168	289	457
Hoshangabad	311	0	6	3	0	0	1	0	0	0	0	321	681	1,002
Indore	329	19	0	0	0	0	5	0	0	0	0	353	42	395
Jabalpur	440	33	1	0	0	0	0	0	0	5	0	479	539	1,018
Jhabua	413	1	2	17	0	0	0	0	0	1	0	434	246	680
Khandwa	498	82	0	0	0	0	1	0	0	0	0	581	500	1,081
Khargone	633	146	0	0	0	0	6	0	0	0	0	785	565	1,350
Mandla	417	29	40	149	27	0	0	0	0	0	0	662	666	1,328
Mandsaur	451	73	0	0	0	0	0	0	0	1	0	525	457	982
Morena	355	33	0	0	0	9	2	0	0	0	0	399	759	1,158
Narsimpur	150	30	4	4	0	0	0	0	0	0	0	188	325	513
Panna	302	98	0	0	0	0	0	0	0	0	0	400	316	716
Raisen	236	25	0	0	0	11	3	1	0	0	0	276	571	847
Rajgarh	365	0	0	0	0	2	1	0	0	0	0	368	250	618
Ratlam	252	0	0	0	0	0	0	0	0	0	0	252	235	487
Rewa	349	50	0	0	0	0	0	0	0	0	0	399	235	634
Sagar	265	17	12	2	0	1	0	0	0	0	0	297	725	1,022
Satna	282	170	0	0	0	0	0	0	0	3	0	455	297	752
Sehore	270	39	0	0	0	1	1	0	0	0	0	311	348	659
Seoni	240	54	2	11	0	0	0	0	0	0	0	307	569	876
Shahdol	466	22	6	13	0	0	0	0	0	1	0	508	895	1,403
Shajapur	260	0	0	0	0	8	3	0	0	0	0	271	349	620
Shivpuri	381	107	0	0	0	0	0	0	0	0	0	488	542	1,030
Sidhi	448	17	0	0	0	0	0	0	0	4	0	469	585	1,054
Tikamgarh	142	0	1	4	0	0	0	0	0	3	0	150	354	504
Ujjain	105	0	0	0	0	1	0	0	0	0	0	106	501	607
Vidisha	275	32	10	3	0	19	9	0	0	0	0	348	390	738
Total	11,881	1584	121	332	29	74	49	1	0	24	0	14,095	16,770	30,865

Notes: Classes*: **1** Exclusively water erosion (>10 tonnes/ha/yr); **2** Water erosion under open forest; **3** Exclusively acid soils; **4** Acid soils under water erosion; **5** Acid soils under open forest; **13** Exclusively sodic soils; **14** Eroded sodic soils; **16** Sodic soils under open forest; **17** Eroded sodic soils under open forest; **18** Mining/Industrial waste; **19** Waterlogged area (Permanent)
Others**: Normal agricultural lands, water-bodies, rivers, lakes and habitats etc. (based on the limited reconnaisance survey)

Source: NBSS&LUP

Damoh, Datia, Gwalior and Tikamgarh districts have less than 200 thousand ha soil erosion affected areas.

Soil acidity is localized, and affected districts by it are Mandla (216 thousand ha), Balaghat (83 thousand ha), Chhindwara (58 thousand ha), Sagar (15 thousand ha) Vidisha (13 thousand ha).

Sodic soils are found in Vidisha (28 thousand ha), Bhind (12 thousand ha), Morena (11 thousand ha), and Datia (4 thousand ha).

Maharashtra

Location

It is situated between 15°44′ to 21°40′ N latitudes and 73°15′ to 80°33′ E longitudes, covering 30.76 M ha (307,713 km^2). It is bounded by Gujarat and Dadra and Nagar Haveli in the north-west; Madhya Pradesh in the north, Andhra Pradesh and Karnataka in the south-west Goa in the south and Arabian sea in the west.

Physiography

The state is divided into Western Konkan coast, Western Ghats (North Sahyadris) and North Deccan plateau. Western Konkan coast is a narrow coastal strip on the western part of the Sahyadris with longitudinal distance of 500 km and a width of 15–20 km. The northern part of the strip covering Thane and Raigad are relatively flat with gently sloping residual hill tops of lateritic exposures. Kalyan, Ulhasnagar and Karjat are in plains with some spurs of Western Ghats such as Matheran hills that attain a height of 700 m above msl.

Western Ghats (North Sahyadris), commonly known as Sahyadris, form western edge of the Deccan plateau with several basaltic lava flows of the height of 1,500 m at places. This chain of mountains extends from south of the Tapi in Gujarat to the tip of Peninsula and forms a physical and cultural barrier between plateau and coastal lowlands. The western edge of the plateau ends abruptly with an escarpment of 600 m height above msl, descending to the coastal lowland of Konkan. These mountains have a crest zone of 15 to 25 km width with dissected hill ranges of precipitous slopes and narrow steep sided valleys. It has also many peaks of varying heights ranging from 901 m (Pondaghat peak) to 1,646 m (Kalsubai peak).

North Deccan (Maharashtra plateau) towards the east of Sahyadris is divided into Upper Maharashtra (Deccan) plateau, Lower Maharashtra (Deccan) plateau and Lower Maharashtra plateau (Metamorphic).

Upper Maharashtra (Deccan) plateau stretches south east and is interspersed with hill ranges like Mahadeva and Ajanta and with mesas and

buttes and broad valleys in-between. It has gently sloping to very gently sloping plains. The broad valley lies in between Ajanta and Mahadeva plateaux with eroded pediment, followed by depositional piedmont merging to flood plains of the Godavari, Bhima and Krishna rivers.

Lower Maharashtra (Deccan) plateau lies in the east of the upper plateau. It has vast plains formed downstream mainly due to the Godavari, Bhima and Krishna rivers. The plains have undulating to rolling lands merging to valleys of flood-plain regions.

Lower Maharashtra plateau (Metamorphic) is exposed all along the Wainganga valley. In Penganga valley, beds consist of quartzites and coal beds of lower Gondwana. Nagpur forms eastern most extension of the plateau.

Geology

The geological formations include Deccan Trap with intertrappen beds of Cretaceous-Ecocene period, Lameta beds of Upper Cretaceous period, Gondwanas of Upper Triassic period, Middle Jurassic and Upper Carbonaceous period, Vindhyan system, Penganga beds and Kaladgi series of Upper Precambarian and Dharwar system, Sausar and Sakoli series of Lower Precambarian times. Maharashtra, in general, is a plateau which is sloping gently towards eastern side of the state. The elevation of the state ranges from 150 to 400 m above msl. The Sahyadris have a crestline of about 1,500 m above msl and have a width of 15–25 km running from north to south.

Climate

The state has subtropical monsoonic climate of humid-per-humid, semi-arid and sub-humid type. The rainy season is mostly confined to south-west monsoon, of which 80% is received during June–October. Western part of the Sahyadris and Konkan coast receives 2,500–4,000 mm rainfall and has marine humid-per-humid climate with more humidity and less diurnal variations. Sahyadris receive highest rainfall of about 4,000 to 6,000 mm. The crest line receives more than 7,000 mm of rainfall

The mean annual temperature ranges from 25° to 28°C, the highest (46°C) being in May and the lowest is (11°C) in December.

The mean maximum temperature of the hottest month in Konkan is 32.7°C. At Nasik, Pune, Kolhapur, it is less than 40°C, while in central and eastern parts, it ranges from 40° to 46°C. The mean minimum temperature of coldest month in the western coast varies from 16° to 29°C, and it ranges from 11° to 15°C in the central, eastern parts of the state. Owing to coastal climate, diurnal and monthly temperature variations in a year in the coast are low as compared to plateau areas.

Natural Vegetation

Forests in the state occupying 6.6 M ha (17%) of the TGA and are distributed in the western, northern and eastern zones that receive relatively heavy rainfalls.

Four types of the forests are: tropical evergreen forests, tropical moist deciduous forests, tropical dry deciduous forests and tropical thorny forests.

Jamun (*Syzygium cumini*), *pisa* (*Actinodaphne angustifolia*), *anjani* (*Memecylon umbellatum*), *hirda* (*Terminalia chebula*), teak (*Tectona grandis*), *arjun* (*Terminalia arjuna*), *haldu* (*Adina cordifolia*), *tiwas* (*Ougeinia dalbergioides*), *khair* (*Acacia catech*), *shivan* (*Gmelina arborea*), *dhavada* (*Anogeissus latifolia*), *salai* (*Boswellia serrata*), *babul* (*Acacia nilotica*), *ber* (*Zizyphus jujuba*), *palas* (*Butea monosperma*) are common species found in the forest areas. Littoral forests have *Casuarina* and mangroves.

Soils

Soils of the state belong to 5 orders and 8 great groups. Entisols (37%), Inceptisols (31%), and Vertisols (26%) are the predominant soils, followed by Alfisols (6%) and Mollisols (<1%). The different great groups are: Rhodustalfs,

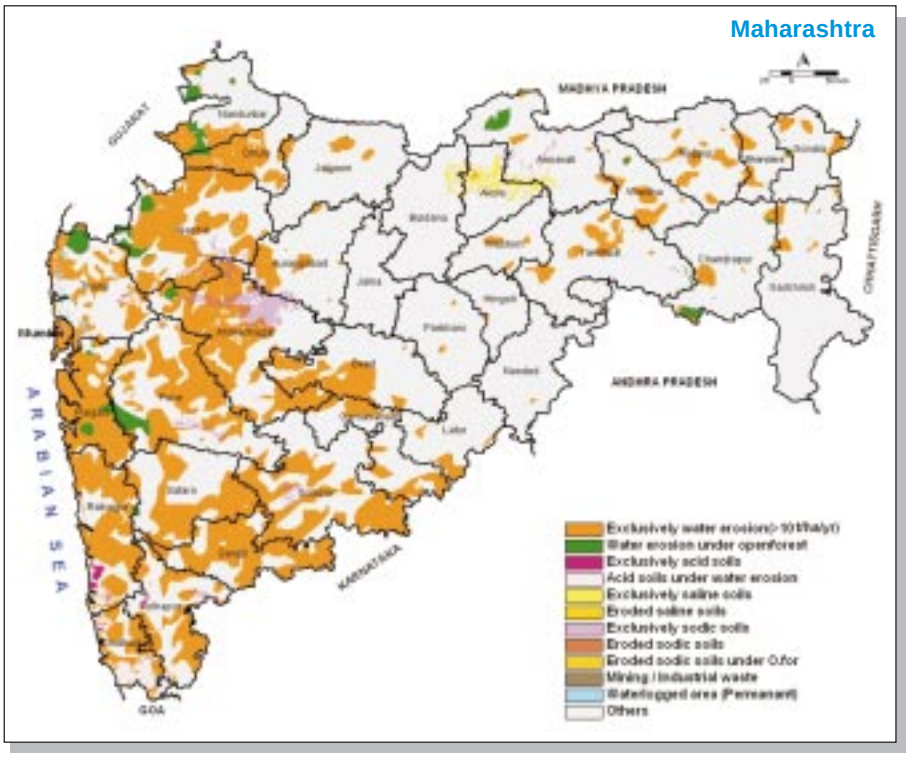

Fig. 32. Degraded and wastelands of Maharashtra
Source: NBSS&LUP

Table 33. Degraded and wastelands statistics of Maharashtra (Area in '000 ha)

Districts (34)	Degraded and wastelands classes*												Others**	Total
	1	2	3	4	7	8	13	14	17	18	19	Total of classes		
Ahmednagar	791	15	0	0	0	0	149	115	1	0	0	1,071	645	1,716
Akola	3	0	0	0	103	6	1	0	0	0	0	113	415	528
Amravati	49	44	0	0	25	0	20	0	0	0	0	138	1077	1,215
Aurangabad	142	0	0	0	0	0	25	6	0	0	0	173	836	1,009
Beed	332	0	0	0	0	0	0	0	0	0	0	332	739	1,071
Bhandara	50	3	0	0	0	0	0	0	0	0	0	53	335	388
Buldana	1	0	0	0	29	0	0	0	0	0	0	30	927	957
Chandrapur	72	31	0	0	0	0	0	0	0	5	0	108	1034	1,142
Dhule	415	18	0	0	0	0	0	0	0	0	0	433	379	812
Gadchiroli	51	1	0	0	0	0	0	0	0	0	0	52	1383	1,435
Gondia	66	1	0	0	0	0	0	1	0	0	0	68	473	541
Hingoli	3	0	0	0	0	0	0	0	0	0	0	3	447	450
Jalgaon	74	2	0	0	0	0	0	0	0	0	0	76	1096	1,172
Jalna	3	0	0	0	0	0	0	0	0	0	0	3	764	767
Kolhapur	333	0	7	14	0	0	9	5	0	0	0	368	405	773
Latur	75	0	0	0	0	0	0	0	0	0	0	75	638	713
Mumbai	58	0	0	0	0	0	0	0	0	0	2	60	1	61
Nagpur	150	1	0	0	0	0	0	0	0	2	0	153	825	978
Nanded	3	0	0	0	0	0	0	0	0	0	0	3	1044	1,047
Nandurbar	107	50	0	0	0	0	0	0	0	0	0	157	348	505
Nashik	836	71	0	0	0	0	21	19	0	0	0	947	619	1,566
Osmanabad	234	0	0	0	0	0	0	0	0	0	0	234	524	758
Parbhani	10	0	0	0	0	0	0	0	0	0	0	10	639	649
Pune	720	68	1	0	0	0	20	6	0	0	0	815	760	1575
Raigad	570	44	0	0	1	0	0	0	0	0	0	615	111	726
Ratnagiri	540	3	25	39	0	0	0	0	0	0	0	607	221	828
Sangli	616	0	0	0	0	0	0	5	0	0	0	621	245	866
Satara	517	7	0	0	0	0	0	0	0	0	0	524	529	1,053
Sindhudurg	255	0	6	166	0	0	0	0	0	0	0	427	88	515
Solapur	683	0	0	0	0	0	13	7	0	0	0	703	793	1,496
Thane	336	57	2	9	4	1	0	0	0	1	25	435	525	960
Wardha	112	6	0	0	0	0	0	0	0	1	0	119	512	631
Washim	30	0	0	0	2	0	0	0	0	0	0	32	481	513
Yavatmal	163	0	0	0	0	0	0	0	0	7	0	170	1,185	1,355
Total	8,400	422	41	228	164	7	258	164	1	16	27	9,728	21,043	30,771

Notes: Classes*: **1** Exclusively water erosion (>10 tonnes/ha/yr); **2** Water erosion under open forest; **3** Exclusively acid soils; **4** Acid soils under water erosion; **7** Exclusively saline soils; **8** Eroded saline soils; **13** Exclusively sodic soils; **14** Eroded sodic soils; **17** Eroded sodic soils under open forest; **18** Mining/Industrial waste; **19** Waterlogged area (Permanent)
Others**: Normal agricultural lands, water-bodies, rivers, lakes and habitats etc. (based on the limited reconnaisance survey)
Source: NBSS&LUP

Haplustalfs, Haplustoll, Ustifluvents, Ustorthents, Halaquepts, Ustropepts, and Chromusterts. (Challa *et al.,* 1995).

Land Use

Out of the total geographical area in the state, 58% of the land is under cultivation and the remaining is either covered with forest or scrub vegetation

or left as culturable waste; 12% of the cultivated area is irrigated. Cropping pattern includes rice-wheat, rice-mustard and rice-chickpea. Cotton is grown in Vidarbha. Sugarcane is grown in western Maharashtra. Presently soybean has been adopted as a cash crop by many farmers. Nashik and Pune districts are famous for vegetables, onion and grape production.

Degraded and Wastelands

Soil erosion coupled with soil acidity is a major problem in western Maharashtra, and soil erosion is a major problem in Vidarbha region (Fig. 32, Table 33).

In this state, about 8,822 thousand ha (about 29% of TGA) is affected by water erosion including erosion under open forest. Highly affected districts are Nashik (836 thousand ha), Ahmednagar (806 thousand ha), Pune (788 thousand ha), Solapur (683 thousand ha), Sangli (616 thousand ha), Raigad (570 thousand ha), and Ratnagiri (543 thousand ha).

Total area under acidic soils (including areas affected by water erosion) covers 269 thousand ha. The Sindhudurg district has an area of 172 thousand ha, followed by Ratnagiri (64 thousand ha) and Kolhapur (21 thousand ha). Highest areas under sodic soils are found in Ahmednagar district (265 thousand ha). Other affected districts are Nashik (40 thousand ha), Aurangabad (31 thousand ha), Pune (26 thousand ha) and Solapur (20 thousand ha).

WESTERN REGION

This region comprises Gujarat and Rajasthan.

Gujarat

Location

The state is located between 20°01′ to 24°07′ N latitudes and 68°04′ to 74°04′ E longitudes. It covers 19.6 M ha (196,024 km^2) and accounts for 6% of the total geographical area (TGA) of the country. It has 1,600 km long coast-line which forms its western and south-western boundary. Its northern boundary shares international border with Pakistan. It is bounded by Rajasthan in the north-east, Madhya Pradesh in the east and Maharashtra in the south and south-east.

Physiography

Depending upon the elevation, slope and ruggedness of the terrain, the state is divided into the Central highlands, the Western hills and the West coast. The Central highlands, a wide belt of hilly region, is bordered in the west by the Aravalli ranges; occupying extreme north-eastern part of the state.

The Western hills represented by Sahyadris form a part of the Peninsular plateau. The northern end of Sahyadris with its characteristic north-south cliff and finger-like east-west spurs transgresses into eastern limits of the state.

The West coast comprising Gujarat plain, Kathiawar Peninsula and Kachchh Peninsular covers major portion of the state. Gujarat plain has progressively built up in the form of successive deltaic plains by the alluvium laid by the Tapi, Narmada, Maji, Sabarmati, Banas and Luni river systems. Kachchh Peninsula comprises a central high plateau surrounded by dissected scarps and flat-topped mesas on all sides, excepting in the east. The Rann of Kachchh, the remnant of a very late marine transgression, is a flat depositional plain of salt, sand and mud, and is marked with scattered islands (*bets*) and Banni.

Geology

The important rock formations are Precambrian, Archaens and Aravallis. The Aravallis are composed of highly metamorphosed quartzites, conglomerates, slates and limestones. Jurassic sandstone is fairly widespread in Kachchh and in the north-eastern part of Kathiawar. The Cretaceous sandstone is observed as outcrops in parts of Wadhwan (Kathiawar) and Sabarkantha. The Kathiawar Peninsula is mostly covered with Eocene basaltic flows having trappean characteristics. Tertiary rocks are mainly exposed along the coastal region of Surat, Bharuch and south-east of Kathiawar and Kachchh. Gypsiferous clay dwarka beds are located along the western coast of Kathiawar. The large alluvial tract spreading from Surat to Banaskantha is of estuarine, aeolian and marine origin. It has been formed by an extensive Pleistocene sedimentation.

Climate

The climate of the state is from arid, through semi-arid, to sub-humid tropical monsoonic type. The mean annual rainfall varies between 300 and 2,800 mm, covering 15 to 80% of the mean annual potential evapotranspiration (PE). The mean annual temperature is 26° to 28°C, with summer temperature ranging between 37° and 42°C and winter between 10° and 18°C.

Natural Vegetation

The wide variations in climate and topography have resulted in vegetal growth from typical desert plants in Kachchh and north-western parts of the state to moist deciduous forests in Dangs and Valsad. *Kajor* concentration in forest is observed all along the eastern border as well as in the hilly parts of Kathiawar but plains are mostly devoid of full-stocked forest cover. The major types of forests covering about 10% area of the state can be grouped as: tropical

moist deciduous, tropical dry deciduous, tropical scrub, dry grasslands and littoral and swampy forests.

Soils

Gujarat soils belong to 5 orders, 11 suborders, 20 great groups and 45 subgroups. Among the different orders, Inceptisols cover 51% of the total area, followed by Entisols, Aridisols, Vertisols and Alfisols covering 14%, 11%, 9% and <1%. Soil great groups identified are Rhodustalfs, Natargids, Salorthids, Fluvaquents, Torripsamments, Ustifluvents and Ustorthents (Sharma *et al.*, 1994).

Land Use

In Gujarat, about 50% of the area is under cultivation, of which, only one-fifth is irrigated. About 10% area is under forests and the remaining 40% is either left barren or unculturable/culturable waste.

Sorghum, pearl millet, groundnut, tobacco, maize, paddy, wheat, mustard constitute major crops. Of the total cropped area, food crops, cereals and pulses account for 50%; the remaining is under oilseeds, fibres and fodder crops.

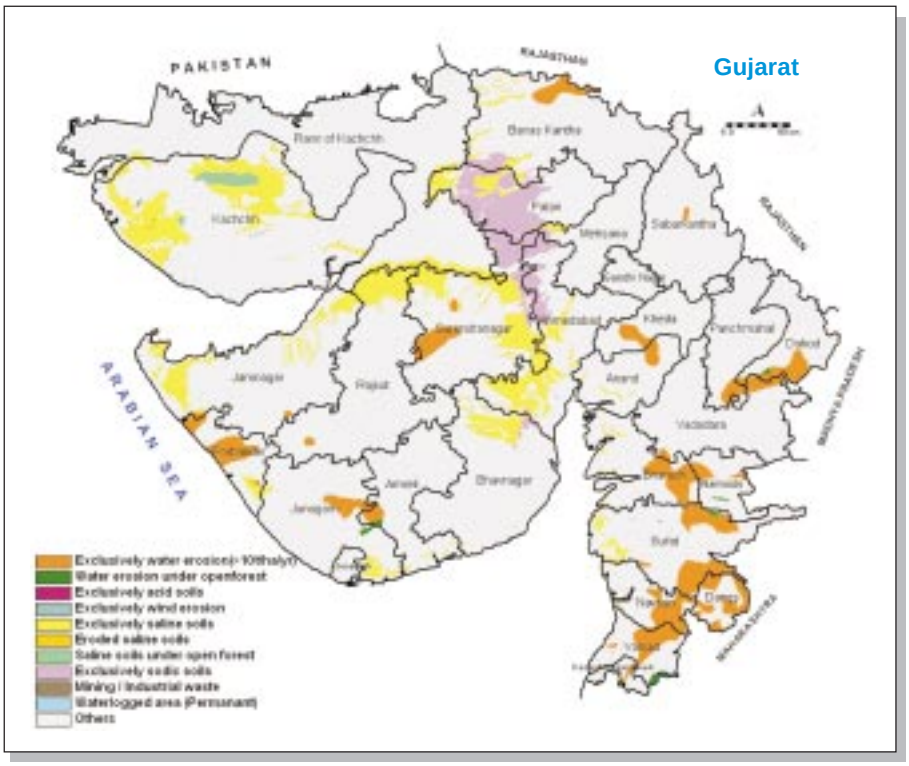

Fig. 33. Degraded and wastelands of Gujarat
Source: NBSS&LUP

Table 34. Degraded and wastelands statistics of Gujarat (Area in '000 ha)

Districts (25)	Degraded and wastelands classes*									Others**	Total
	1	2	7	8	11	13	18	19	Total of classes		
Ahmedabad	0	0	159	0	0	96	0	0	255	549	884
Amreli	26	5	7	0	0	0	1	0	39	704	743
Anand	18	0	7	0	0	0	0	0	25	270	295
Banaskantha	55	0	47	0	0	42	0	0	144	935	1079
Bharuch	114	0	20	0	0	0	1	0	135	519	654
Bhavnagar	0	0	77	0	0	14	0	0	91	905	996
Dahod	57	3	0	0	0	0	0	0	60	307	367
Dangs	84	0	0	0	0	0	0	0	84	94	178
Gandhi Nagar	0	0	0	0	0	0	0	0	0	217	217
Jamnagar	9	0	185	1	0	0	1	0	196	1,206	1402
Junagarh	42	6	29	0	0	0	0	0	77	809	886
Kachchh	0	0	519	0	60	11	5	0	595	3,948	4543
Kheda	35	0	0	0	0	0	0	0	35	388	423
Mehsana	0	0	9	0	0	10	0	0	19	420	439
Narmada	27	3	0	0	0	0	0	0	30	246	276
Navasari	66	0	5	0	0	0	1	0	72	150	222
Panchmahal	24	0	0	0	0	0	0	0	24	500	524
Patan	0	0	63	0	0	253	0	0	317	269	586
Porbandar	67	0	10	3	0	0	0	0	80	151	231
Rajkot	9	0	106	0	0	0	0	0	115	999	1114
Sabarkantha	5	0	0	0	0	0	0	0	5	737	742
Surat	156	4	29	0	0	0	3	0	192	587	779
Surendranagar	62	0	222	3	0	119	1	0	404	637	1041
Vadodara	41	0	0	0	0	0	0	0	41	716	757
Valsad	82	11	1	0	0	0	0	1	95	210	305
Total	979	32	1,495	4	60	545	12	1	3,129	16,473	19683

Notes: Classes*: **1** Exclusively water erosion (>10 tonnes/ha/yr); **2** Water erosion under open forest; **7** Exclusively saline soils; **8** Eroded saline soils; **11** Saline soils under open forest; **13** Exclusively sodic soils; **18** Mining/ Industrial waste; **19** Waterlogged area (Permanent)
Others**: Normal agricultural lands, water-bodies, rivers, lakes and habitats etc. (based on the limited reconnaisance survey)
Source: NBSS&LUP

Degraded and Wastelands

Total degraded area in the state is 3,129 thousand ha (about 16% of TGA). The highly affected districts are: Kachchh (595 thousand ha), Surendranagar (404 thousand ha), Patan (317 thousand ha), Jamnagar (196 thousand ha) and Surat (192 thousand ha) (Fig. 33; Table 34).

Among districts affected by water erosion, Surat ranks first with 160 thousand ha, followed by Bharuch (114 thousand ha), Valsad (93 thousand ha), Dangs (84 thousand ha), Porbandar (67 thousand ha), Navasari (66 thousand ha), Dahod (60 thousand ha) and Banaskantha (55 thousand ha). This includes erosion in open forest area also. Saline soils account for 1,559 thousand ha (8% TGA); of which 579 thousand ha is found in Kachchh. Other areas affected by salinity are Surendranagar (222 thousand ha), Jamnagar (186 thousand ha),

Ahmedabad (159 thousand ha) and Rajkot (106 thousand ha). Sodicity is also a major problem in Gujarat. Sodicity affected areas account for 545 thousand ha and highly affected districts are Kachchh (468 thousand ha), Patan (253 thousand ha), Surendranagar (119 thousand ha) and Ahmedabad (96 thousand ha). Wind erosion is observed in Patan district.

Rajasthan

Location

Rajasthan is located between 69°30′ to 78°17′ E longitudes and 23°30′ to 30°12′ N latitudes, covering about 34.22 M ha (342,239 km^2); which accounts for 11% of the total area of the country. The state is bounded in the west by Pakistan, in the north by Haryana and Punjab, in the east by Uttar Pradesh and Madhya Pradesh, and in the south by Gujarat.

Physiography

The state has been demarcated into Western plain with two sub-physiographic zones namely, the sandy arid plain and the semi-arid transitional plain. And the Central highlands with four sub-zones, the Aravalli landscape, the Eastern Rajasthan upland, the Pathar and Bundelkhand uplands, and the Malwa plateau. The sandy arid plain and the arid pediplain constitute a part of the Thar Desert in the western Rajasthan. The sandy arid plain is dotted by both stabilized and continuously shifting sand-dunes. The semi-arid transitional plain lies roughly between eastern margins of the western desert and western foothills of Aravallis. The Central highlands constitute mainly discontinuous hilly tracts of Aravallis, extending diagonally from north-east to south-west of the state. The eastern Rajasthan upland includes eastern and north-eastern side areas of the Aravalli range, and is formed by the alluvium of the Banas and Mahi river system. The Pathar and Bundelkhand uplands are primarily the hilly regions of the Vindhyan system. The Malwa plateau consists of Deccan trap and abounds in basaltic formations.

Geology

The state can be broadly divided into three natural regions: Aeolian sands, Alluvium and Aravallis.

The Aeolian deposits belong to Pleistocene and recent times. And the dune-free areas of Barmer, Bikaner and Jaisalmer contain exposed marine deposits of Jurassic and Eocene periods, showing an anamoly in the nature of rock deposits of the region. Besides, the Vindhyan system crops out around Jodhpur, where there are small patches of Malani volcanic and granite rocks formations.

The alluvium, covering a part of the eastern plain, south-eastern plain and flood plain, belongs to the recent and sub-recent periods. The ravines flanking the river Chambal and its tributaries are of recent origin.

The entire rock system of the state belongs to Palaeozoic, Proterozoic and Archaen era. The Aravalli system is largely composed of argillaceous deposits, metamorphosed to mica schists, which crop out around Alwar, Udaipur, Ajmer and their surroundings. The Deccan trap covers south-eastern part of the state forming Malwa plateau.

Climate

It ranges from semi-arid to arid on the west of Aravallis and semi-arid to sub-humid on the east of Aravallis.

The mean annual rainfall in the western Rajasthan varies from 100 to 400 mm, and it ranges between 557 mm and 1,000 mm in the east. And the mean annual temperature ranges between 24° and 27°C. In the western part, higher average temperature recorded in the months of May and June is around 40°–43°C; mean winter temperature drops to 13°C during December to January.

Natural Vegetation

In the western region, sparse vegetal cover comprises mainly xerophytic plants, which are thorny and have stunted growth. The dominant species are *babul* (*Acacia nilotica*), *Acacia senegal, Prosopis cineraria* and *Prosopis juliflora.* In depressions (generally saline), halophytes are observed. The eastern region has vegetation ranging from mixed deciduous forests to subtropical evergreen forests, but it has been adversely affected by reckless cutting and grazing. Forest in the eastern sector comprise *dhikra, salar, gurgan, anwal, tendu, khair, neem, mahuva, jamun, babul* and teak. Grass species also abound, these are dominated by *ratarda, Cenchrus ciliaris, Sehima nervosum, Chloris barbata, Iseilema laxum, Dichanthium annulatum, Chrysopogon montanus* and *Cynodon dactylon.*

Soils

Rajasthan soils have been classified into 5 orders, 8 suborders, 16 great groups and 32 subgroups. The Entisols are observed to cover around 36% area, followed by Inceptisols, Aridisols, Vertisols and Alfisols with 23%, 20%, 2% and < 1% of TGA (Shyampura and Sehgal, 1995). The soil mapping unit rock outcrops and active dunes together cover 99.7% of TGA, and salt flats, water-bodies and habitation constitute only 0.3%.

Land Use

Around 50% of its total geographical area is under cultivation, and 7% area

is occupied by deciduous and evergreen forests, and remaining 43% area is barren or is uncultivable/culturable waste. Around 50% of the total cropped area is occupied by cereals and pulses, and the remaining is under oilseeds and fibre crops.

Degraded and Wastelands

Total degraded lands in the state account for 20,424 thousand ha (54% of TGA). Among districts, Jaisalmer is highly degraded with 2,772 thousand ha, followed by Bikaner (2,120 thousand ha), Barmer (1,922 thousand ha), Churu (1,381 thousand ha), Jodhpur (1,241 thousand ha) and Udaipur (1,014 thousand ha) (Fig. 34; Table 35).

In the state, wind erosion is a major contributor to land degradation; it affects 11,419 thousand ha. Highly affected districts are Jaisalmer (2,753 thousand ha), Bikaner (2,119 thousand ha), Barmer (1,908 thousand ha), Churu (1,346 thousand ha) and Jodhpur (1,235 thousand ha).

Water erosion is very prominent in Udaipur (986 thousand ha), Chittorgarh (633 thousand ha), Bhilwara (571 thousand ha), Baran (564 thousand ha) and Bundi (539 thousand ha). Saline soils (82 thousand ha) are mostly found in Bhilwara, Bharatpur, Alwar, Ajmer, Tonk and Jaipur, and sodic soils are in Alwar,

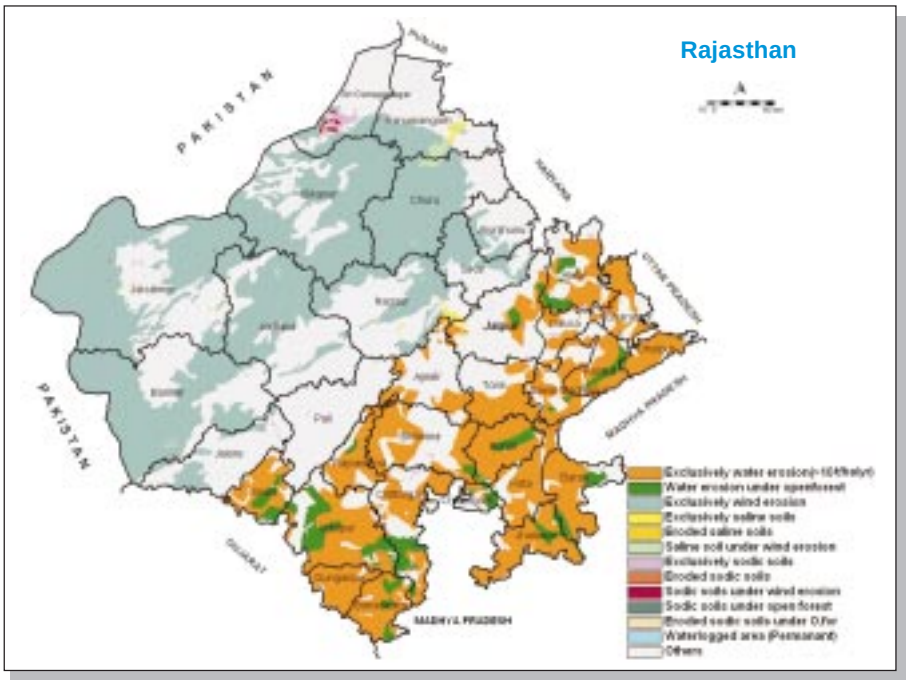

Fig. 34. Degraded and wastelands of Rajasthan
Source: NBSS&LUP

Table 35. Degraded and wastelands statistics of Rajasthan (Area in '000 ha)

Districts (37)	Degraded and wastelands classes*												Others**	Total
	1	2	6	7	8	10	13	14	15	16	17	Total of classes		
Ajmer	275	0	1	0	3	0	4	3	0	0	0	286	559	845
Alwar	358	102	0	0	1	0	11	6	0	0	0	478	356	834
Banaswara	387	78	0	0	0	0	0	0	0	0	0	465	37	502
Baran	480	84	0	0	0	0	0	0	0	0	0	564	133	697
Barmer	0	0	1,908	0	0	10	2	0	2	0	0	1,922	930	2,852
Bharatpur	297	3	0	0	0	0	0	0	1	0	0	301	205	506
Bhilwara	552	19	0	0	0	0	5	1	0	0	0	577	466	1,043
Bikaner	1	0	2,119	0	0	0	0	0	0	0	0	2,120	626	2,746
Bundi	448	91	0	0	0	0	0	0	0	0	0	539	15	554
Chittorgarh	466	167	0	0	0	0	9	3	0	0	0	645	435	1,080
Churu	0	0	1,346	0	0	35	0	0	0	0	0	1,381	314	1,695
Dausa	134	3	0	1	0	0	5	0	0	0	0	143	199	342
Dholpur	253	10	0	0	0	0	0	0	0	0	0	263	41	304
Dungarpur	357	0	0	0	0	0	0	2	0	0	0	359	19	378
Hanumangarh	0	0	320	26	0	52	2	0	0	0	0	400	860	1,260
Jaipur	215	41	0	9	4	0	1	0	0	0	0	270	836	1,106
Jaisalmer	0	0	2,753	10	0	1	6	0	2	0	0	2,772	1,091	3,863
Jalore	4	0	244	1	0	1	7	0	1	0	0	258	801	1,059
Jhalawar	501	70	0	0	0	0	0	0	0	0	0	571	50	621
Jhunjhunu	0	0	149	0	0	0	0	0	0	0	0	149	442	591
Jodhpur	0	0	1,235	1	0	5	0	0	0	0	0	1,241	1,042	2,283
Karauli	353	78	0	0	0	0	0	0	0	0	0	431	120	551
Kota	417	9	0	0	0	0	0	0	0	0	0	426	119	545
Nagaur	7	0	735	25	0	6	0	0	0	0	0	773	995	1,768
Pali	21	3	1	0	0	0	2	0	0	0	0	27	1,202	1,229
Rajsamand	275	13	0	0	0	0	0	0	0	0	0	288	98	386
Sawai Madhopur	263	12	0	0	0	0	1	0	0	0	0	276	173	449
Sikar	0	0	414	0	0	0	0	0	0	0	0	414	361	775
Sirohi	303	105	0	1	0	0	0	0	0	0	0	409	102	511
Sri Ganaganagar	0	1	194	0	0	0	53	0	24	0	0	272	529	801
Tonk	390	0	0	0	0	0	0	0	0	0	0	390	327	717
Udaipur	679	307	0	0	0	0	0	11	0	1	16	1,014	317	1,331
Total	7,436	1,196	11,419	74	8	110	108	26	30	1	16	20,424	13,800	34,224

Notes: Classes*: 1 Exclusively water erosion (>10 tonnes/ha/yr); **2** Water erosion under open forest; **6** Exclusively wind erosion; **7** Exclusively saline soils; **8** Eroded saline soils; **10** Saline soils under wind erosion; **13** Exclusively sodic soils; **14** Eroded sodic soils; **15** Sodic soils under wind erosion; **16** Sodic soils under open forest; **17** Eroded sodic soils under open forest

Others**: Normal agricultural lands, water-bodies, rivers, lakes and habitats etc. (based on the limited reconnaisance survey)

Source: NBSS&LUP

Ajmer, Chittorgarh, Dungarpur, Udaipur and Sri Ganganagar.

Saline soils cover an area of 82 thousand ha, mostly confined to Hanumangarh, Nagaur, Jaipur and Jaisalmer districts. Sodic soils account 181 thousand ha. Sodicity affected districts are Sri Ganganagar, Alwar and Udaipur.

SOUTHERN REGION

The southern region comprises Andhra Pradesh, Goa, Karnataka, Kerala and Tamil Nadu.

Andhra Pradesh

Location

Andhra Pradesh is one of the four littoral states of India that borders the Bay of Bengal. It is located between 12°37′ and 19°54′ N latitudes and 76°46′ and 84°46′ E longitudes. It is the fifth largest state in India with 27.5 M ha (275,045 km^2), accounting for 8.4% of the TGA of the country.

The state is bounded by Maharashtra in the north, Madhya Pradesh and Orissa in the north-east, Tamil Nadu in the south, Karnataka and Maharashtra in the west, and the Bay of Bengal in the east. It has a vast sea-coast that stretches nearly 972-km long.

Physiography

The state has been divided into Deccan plateau, Hill ranges and Coastal plains.These have been further subdivided based on their geographic locations into South Deccan plateau, Eastern Ghats (North), Eastern Ghats (South), and East Coastal (Andhra) plains.

Geology

The state is endowed with Archaean, Precambrian, Paleozoic, Carboniferous, Triassic, Cretaceous, Mesozoic, Tertiary, Miocene, Pliocene, Pleistocene and Recent formations.

The Archaeans or peninsular gneisses cover about two-thirds of Telangana and Rayalaseema regions. These are igneous rocks, partially metamorphosed, which have remained stable as a "Shield" area for a very long time. The important rock types are granites, granodiorites and banded gneisses. In some areas, the Peninsular gneisses are traversed by a number of dolerite dykes. The Dharwars mainly consist of schists and quartzites, and are folded and highly metamorphosed.

Climate

The state presents a transition from tropical to sub-tropical monsoonic climate, from semi-arid to arid type in Telangana and Rayalaseema regions, and humid to sub-humid in the coastal regions. The average annual rainfall is 830 mm, which varies from 690 mm in Rayalaseema to 860 mm in Telangana and 950 mm in the coastal region. The average annual temperature is 29°C and

varies from 22°C to 35°C. The highest (44°C) is in May and the lowest (12°C) is in January.

Natural Vegetation

The forests in the state occupy about 6.3 M ha (23%) of the area; mainly in the northern, north-eastern, eastern, south-eastern and central zones having relatively higher rainfall. Ecologically forests identified are: southern tropical dry deciduous forests, south Indian moist deciduous forests, south Indian dry evergreen forests, southern thorn forests, miscellaneous forests, and littoral forests.

Principal forest species include *Terminalia tomentosa, Shorea roxburghii, Anogeissus latifolia, Pterocarpus santalinus, Morinda tinctoria, Zizyphus jujuba, Acacia suma, Acacia nilotica, Albizia lebbeck, Hardwickia binata, Madhuca indica, Dalbergia sissoo, Bambusa arundinacea, Phoenix sylvestris and Borassus flabellifer.* Unculturable wastelands are covered with thorny bushes and tall grasses.

Soils

The soils of the state belong to 6 orders. Of the total area of state, nearly 36% is covered by Inceptisols, 30% by Alfisols, 11% by Entisols, 8% by Vertisols,

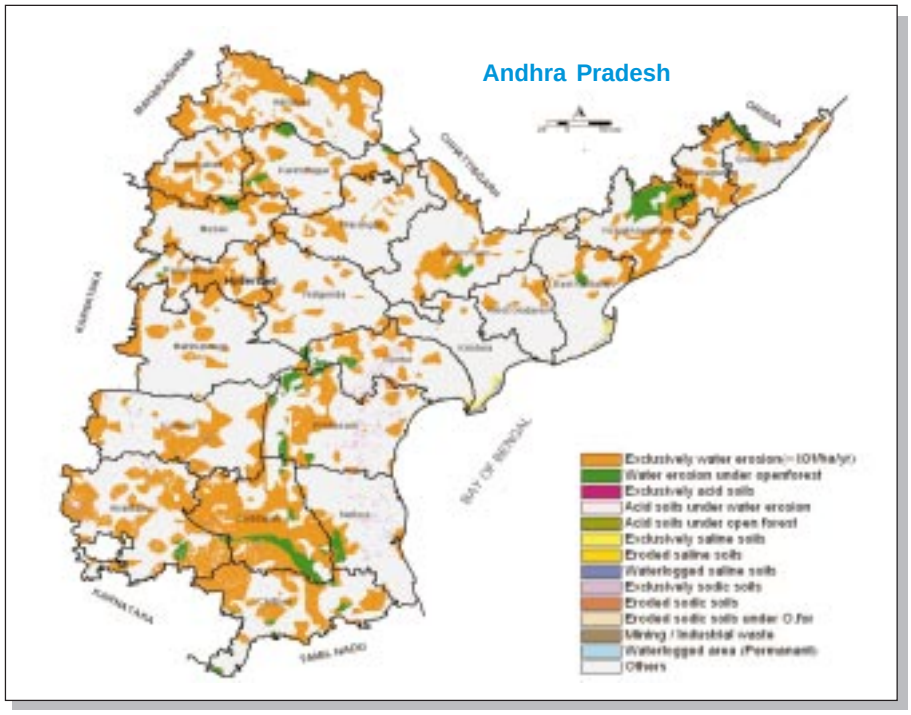

Fig. 35. Degraded and wastelands of Andhra Pradesh
Source: NBSS&LUP

3% by Aridisols and nearly 2% by Mollisols. About 10% of the area is covered by rock land and other miscellaneous lands (Reddy *et al.,* 1996). There are 238 soil family associations, each consisting of dominant, subdominant and other soil family inclusions.

Land Use

Agriculture is the mainstay of nearly 73% of the population. Traditional agriculture predominates, excepting in the coastal and irrigated areas, where high-intensity agriculture is practised.

Of the total geographical area of the state, about 40% is under cultivation, which is below the national average of 45%. The net cropped area has remained

Table 36. Degraded and wastelands statistics of Andhra Pradesh (Area in '000 ha)

Districts (22)	Degraded and wastelands classes*														Others**	Total
	1	2	3	4	5	7	8	12	13	14	17	18	19	Total of classes		
Adilabad	780	12	0	0	0	0	0	0	0	0	0	2	0	794	824	1618
Anantapur	798	33	0	0	0	0	0	0	14	18	0	3	0	866	1051	1917
Chittoor	625	44	0	0	0	0	0	0	0	0	0	0	0	669	849	1518
Cuddapah	988	161	0	0	0	0	0	0	1	7	1	2	0	1160	385	1545
East Godavari	145	18	0	0	0	20	0	7	0	0	0	1	5	196	882	1078
Guntur	235	43	0	0	0	6	0	0	33	5	0	1	0	323	814	1137
Karimnagar	294	59	0	0	0	0	0	0	0	0	0	5	0	358	824	1182
Khammam	356	26	0	0	0	0	0	0	0	0	0	2	0	384	1217	1601
Krishna	41	0	0	0	0	26	0	9	0	0	0	2	6	84	785	869
Kurnool	529	2	0	0	0	0	0	1	6	0	0	11	0	549	1217	1766
Mahbubnagar	354	5	0	0	0	0	0	0	0	0	0	0	0	359	1480	1839
Medak	279	20	0	0	0	0	0	0	0	0	0	0	0	299	671	970
Nalgonda	230	7	0	0	0	0	0	0	0	0	0	1	0	238	1182	1420
Nellore	136	45	0	0	0	0	0	0	42	1	0	0	3	227	1077	1304
Nizamabad	347	13	0	0	0	0	0	0	0	0	0	0	0	360	437	797
Prakasam	418	102	0	0	0	0	0	0	58	8	0	3	1	590	1171	1761
Rangareddi and Hyderabad	330	8	0	0	0	0	0	0	0	0	0	2	0	340	432	772
Srikakulam	188	25	0	0	0	2	4	0	0	0	0	0	2	221	363	584
Vishakha-patnam	319	157	0	0	0	0	0	0	0	0	0	1	1	478	639	1117
Vizianagaram	337	34	0	0	0	0	0	0	0	0	0	1	0	372	284	656
Warrangal	240	0	0	0	0	0	0	0	0	0	0	1	0	241	1041	1282
West Godavari	81	0	0	0	0	2	0	0	0	0	0	1	1	85	687	772
Total	8050	814	0	0	0	56	4	17	154	39	1	39	19	9193	18312	27505

Notes: Classes*: **1** Exclusively water erosion (>10 tonnes/ha/yr); **2** Water erosion under open forest; **3** Exclusively acid soils; **4** Acid soils under water erosion; **5** Acid soils under open forest; **7** Exclusively saline soils; **8** Eroded saline soils; **12** Waterlogged saline soils; **13** Exclusively sodic soils; **14** Eroded sodic soils; **17** Eroded sodic soils under open forest; **18** Mining/Industrial waste; **19** Waterlogged area (Permanent)
Others**: Normal agricultural lands, water-bodies, rivers, lakes and habitats etc. (based on the limited reconnaisance survey)
Source: NBSS&LUP

almost the same between 40 and 41% since the past four decades. An increase in the area under forests has been observed since nineties; owing to government policies of social forestry programmes.

Of the total cropped area (13 M ha), 46% is cultivated with paddy, sorghum, maize and millets.

Degraded and Wastelands

Total area of degraded lands in the state is about 9,193 thousand ha, constituting 33% of TGA. Area affected by water erosion is 8,050 thousand ha (29% of TGA). Excessive soil loss due to water erosion has been observed in almost all districts excepting Krishna and West Godavari. Cuddapah district (988 thousand ha) showed highest loss, followed by Anantapur (798 thousand ha), Adilabad (780 thousand ha), Chittoor (625 thousand ha) and Prakasam (418 thousand ha). Water erosion under open forest remained highest in Cuddapah district (161 thousand ha), followed by Vishakhapatnam (157 thousand ha) and Prakasam (102 thousand ha) (Fig. 35; Table 36).

Saline soils account for 77 thousand ha, including saline soil in waterlogged and partly eroded areas also, and they are predominant in Krishna and East Godavari districts.

And total affected area by sodicity accounts for 194 thousand ha and occurs predominantly in Prakasam, Nellore, Guntur and Anantapur.

Out of the 22 districts, wastelands due to mining activity are found in 20 districts, Kurnool, Karimnagar and Anantapur are the prominent ones, where lands have been rendered wasteland to a large extent.

Goa

Location

The state is situated between 14°53′47″ to 15°47′59″N latitudes and 73°40′54″ to 74°20′11″ E longitudes. It covers an area of 0.37 M ha (3,702 km^2) and accounts for about 1% of the total geographical area of the country. The state is bounded in the west by the Arabian Sea, in north by Maharashtra, and in the east-south by Karnataka.

Physiography

Goa is divided into Konkan coast and Central Sahyadri. The Konkan coast is subdivided into fluvio-littoral marine landform and dissected hilly laterite landform and the Central Sahyadri into granite and granite-gneiss landform, quartzite/schistose landform and basalt landform.

Geology

Goa is almost covered by rocks of the Goa group belonging to the Dharwar Super group of the Archaean/Proterozoic age, excepting a narrow strip at the north-eastern corner that is occupied by Deccan Trap of the Upper Cretaceous to Lower Eocene age. The Goa group consisting of green schist species of metamorphic rock is divided into Barcem formation, Sanvordem formation, Bicholim formation and Vageri formation in the ascending order of superposition. This group is correlated with the Chitradurga group of Karnataka and has been intruded by granite-gneiss, felspathic gneiss, hornblendegranite and porphyritic granite. These intrusions have been recognized as Peninsular gneisses in the contiguous areas of Karnataka as a basement to the Dharwar Super group in the Shimoga-Goa schist belt. These rocks are overlaid by Deccan traps represented by massive and vesicular metabasalt.

Climate

The state has a warm tropical climate with an average annual temperature of 26.4°C; December to February weather is cool and pleasant. Difference between the mean annual summer temperature and mean annual winter temperature is 4°C. South-west monsoon provides a total annual precipitation of about 3,265 mm from June to October.

Natural Vegetation

Vegetation of Goa consists of dense forests of dry to moist deciduous types. Moderately sloping lands with laterite outcrops are covered by grass and shrubs. Evergreen forests are seen only on the high hills. The coastal tracts with marine alluvium are mainly covered by palms. The border-line of Arabian Sea and the west coast are thickly palm-fringed with a small area covered by mangroves. Patches of scrub vegetation with other xerophytic plants (growing on rocks, sand or gravels of which substratum is physically dry) are found in association with tropical fruit-trees, jackfruit and cashew.

Soils

They belong to 4 orders, 7 suborders, 12 great groups and 18 subgroups (Soil Survey staff, 1992). Prominent great groups are: Paleustalfs, Haplustalfs, Psammaquents, Ustipsamments, Ustorthents, Tropaquepts, Humitropepts, Ustropepts, Dystropepts, Haplustults, Kanhaplustults and Paleustults (Harindranath *et al.,* 1999).

Land Use

The cultivable, agricultural and plantation area has reduced from 326,671

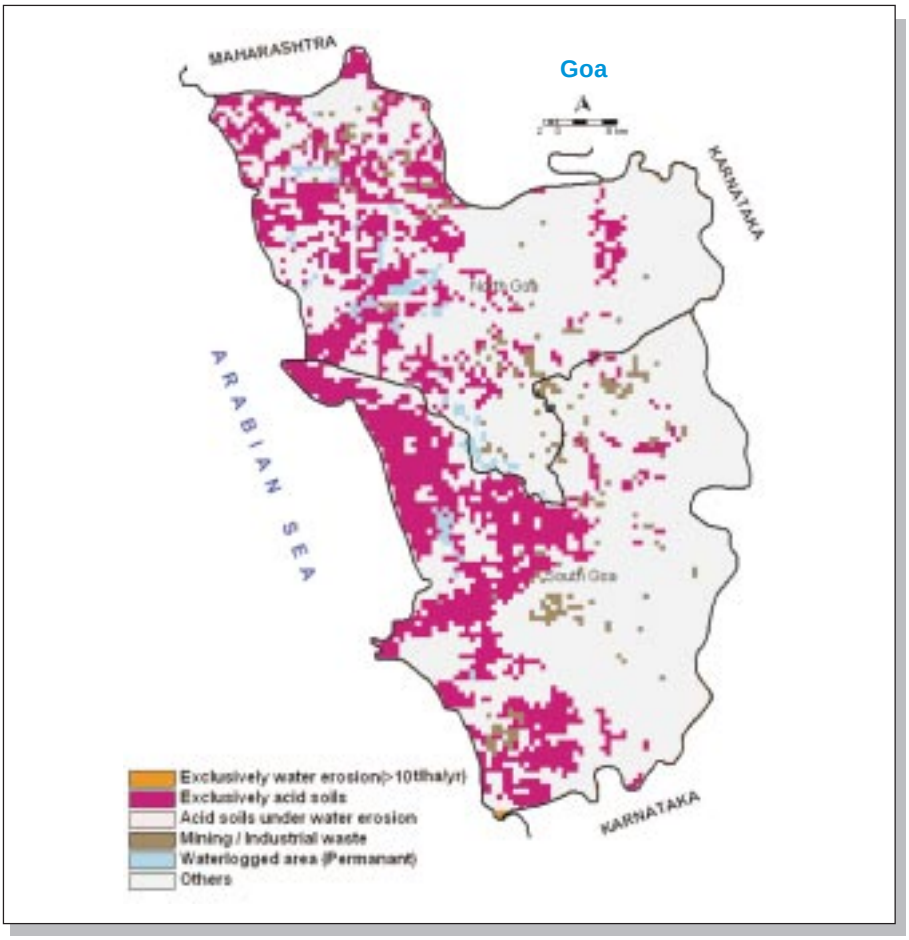

Fig. 36. Degraded and wastelands of Goa
Source: NBSS&LUP

Table 37. Degraded and wastelands statistics of Goa (Area in '000 ha)

Districts (2)	Degraded and wasteland classes*						Others**	Total
	1	3	4	18	19	Total of classes		
North Goa	0	46	0	5	5	56	117	173
South Goa	1	57	0	7	1	66	131	197
Total	1	103	0	12	6	122	248	370

Notes: Classes*: **1** Exclusively water erosion (>10 tonnes/ha/yr); **3** Exclusively acid soils; **4** Acid soils under water erosion; **18** Mining/Industrial waste; **19** Waterlogged area (Permanent)
Others**: Normal agricultural lands, water-bodies, rivers, lakes and habitats etc. (based on the limited reconnaisance survey)
Source: NBSS&LUP

ha during 1989–90 to 323,976 ha in 1992–93. There has been 6% increase in forest area during the last 5 years. The area sown more than once fluctuates between 3 and 6%. Conversely there has been a decrease in the area of cultivable wasteland from 21 to 16%. This indicates an awareness of the people to use irrigation potential for double cropping and greening of the state. Large areas in Sanguem, Sattari, Canacona and Quepem *talukas* are under woodland forests and cultivable wastelands.

The principal crops are paddy, coconut, cashew and pulses. An upward trend in the area under *rabi* paddy and pulses has been observed in the state.

Degraded and Wastelands

Degraded and wastelands account for 122 thousand ha, which is about 33% of TGA of the state. Acid soils (*p*H <5.5), a major problem, account for 103 thousand ha, which is about 28% of TGA of the state. Mining is one of the major concerns causing land degradation. About 12 thousand ha have been rendered wastelands due to mining (3% of TGA). South Goa has more degraded area compared to North Goa (Fig.36; Table 37).

Karnataka

Location

Karnataka is situated between 11°30′ to 18°30′ N latitudes and 74°15′ to 78°30′ E longitudes and covers 19.1 M ha (191,791 km^2). It is bounded by Goa in the north-west, Maharashtra in the north, Andhra Pradesh in the east, Tamil Nadu in the south and south-east and Kerala in the south-west.

Physiography

The state is divided into Deccan plateau, Hill ranges and Coastal plain. These have been subdivided into south Deccan plateau, Western Ghats, Eastern Ghats and West Coastal plains. The elevation of the state ranges between 10 and 300 m above msl in the West Coastal plains and 900 to 1,500 m above msl in the Eastern Ghats.

Geology

The important formations are of Archaean group, Proterozoic, Mesozoic and Cainozoic rocks. The Archaeans or Peninsular gneisses are the oldest formations and cover about 60% of the state. The chief rocks are gneisses, granites and charnockites. Kaladgi and Bhima formations of the upper Proterozoic occur in the northern part of the state. Deccan traps of Mesozoic are found in the extreme north-eastern part, and laterites of Cainozoic occur in

the southern parts of the state. Recent alluvium deposits are found in the river and stream valleys (Reddy *et al.,* 1998).

Climate

It varies from arid to semi-arid in the plateau region, sub-humid to humid tropical in the Ghat region and humid tropical monsoonic type in the West Coast plains. The mean annual temperature ranges from 20.3° to 27.6°C, and the rainfall varies from 350 mm to 1,000 mm in the Plateau region, from 2,700 to 5,000 mm in the Western Ghats, and in the West Coastal plains from 3,000 to 3,600 mm annually.

Natural Vegetation

About 16% of the state is under forests. The evergreen and semi-evergreen

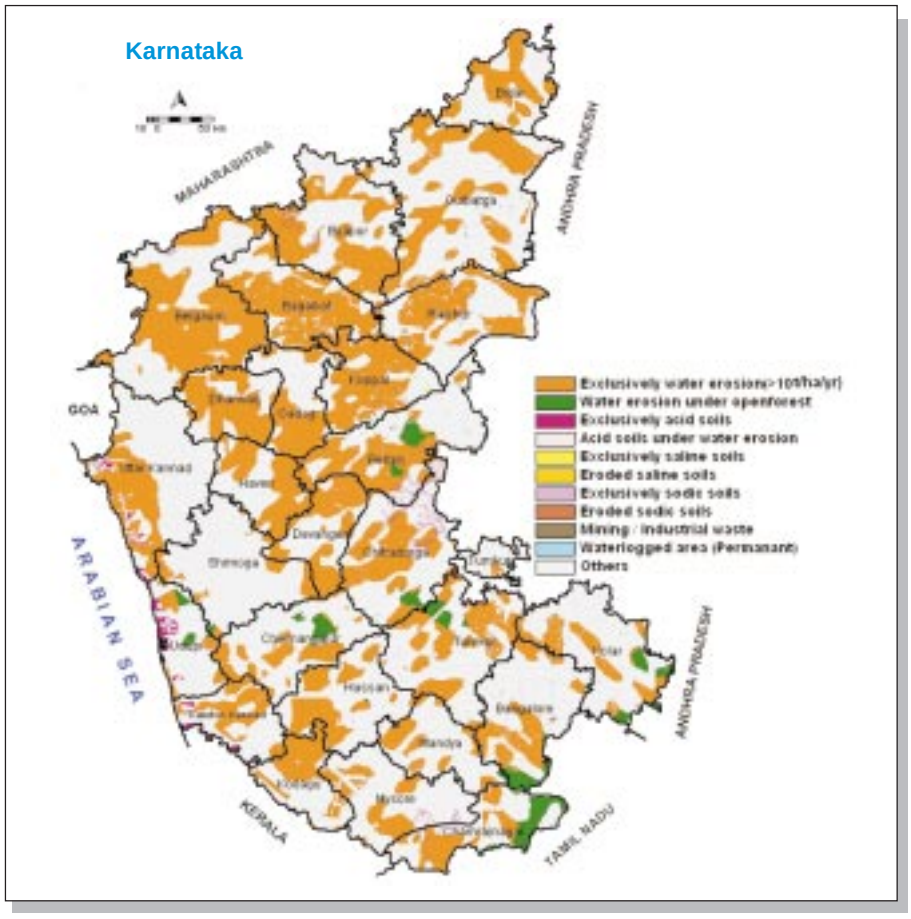

Fig. 37. Degraded and wastelands map of Karnataka
Source: NBSS&LUP

Table 38. Degraded and wastelands statistics of Karnataka (Area in '000 ha)

Districts (26)	Degraded and wastelands classes*											Others	Total
	1	2	3	4	7	8	13	14	18	19	Total of classes		
Bagalkot	452	0	0	0	0	0	0	1	0	0	453	206	659
Bengaluru	216	45	0	0	0	0	0	0	6	0	267	534	801
Belgaum	795	0	0	2	0	0	8	0	0	0	805	537	1,342
Bellary	314	45	0	0	0	0	13	3	9	0	384	461	845
Bidar	246	0	0	0	0	0	0	0	0	0	246	299	545
Bijapur	483	0	0	0	0	0	5	19	1	0	508	542	1,050
Chamrajnagar	154	82	0	0	0	0	6	6	0	0	248	264	512
Chikmagalur	174	39	0	0	0	0	0	15	1	0	229	507	736
Chitradurga	303	22	0	0	0	0	50	0	2	0	377	452	829
Dakshin Kannada	168	0	18	4	0	0	0	0	0	0	190	267	457
Devangere	341	0	0	0	0	0	0	0	1	0	342	251	593
Dharwad	277	0	0	0	0	0	0	0	0	0	277	150	427
Gadag	226	0	0	0	0	0	0	0	0	0	226	239	465
Gulbarga	566	1	0	0	0	0	0	0	6	0	573	1047	1,620
Hassan	243	1	0	0	0	0	0	0	1	0	245	435	680
Haveri	266	0	0	0	0	0	0	0	0	0	266	216	482
Kodagu	184	0	1	0	0	0	0	0	0	0	185	224	409
Kolar	176	48	0	0	0	0	0	0	3	0	227	594	821
Koppal	477	1	0	0	2	0	0	0	7	0	487	232	719
Mandya	133	6	0	0	0	0	0	0	2	0	141	355	496
Mysore	151	0	0	0	0	0	14	0	0	0	165	519	684
Raichur	316	0	0	0	0	0	1	4	4	0	325	357	682
Shimoga	93	4	0	0	0	0	0	0	0	0	97	748	845
Tumkur	339	35	0	0	0	0	0	0	8	0	382	679	1,061
Udupi	55	20	34	4	0	0	0	0	0	1	114	277	391
Uttar Kannada	302	0	16	14	0	0	0	0	0	2	334	694	1,028
Total	7,450	349	69	24	2	0	97	48	51	3	8,093	11,086	19,179

Notes: Classes*: **1** Exclusively water erosion (>10 tonnes/ha/yr); **2** Water erosion under open forest; **3** Exclusively acid soils; **4** Acid soils under water erosion; **7** Exclusively saline soils; **8** Eroded saline soils; **13** Exclusively sodic soils; **14** Eroded sodic soils; **18** Mining/Industrial waste; **19** Waterlogged area (Permanent)
Others**: Normal agricultural lands, water-bodies, rivers, lakes and habitats etc. (based on the limited reconnaisance survey)
Source: NBSS&LUP

forests include *Dipterocarpus indicus, Calophyllum tomentosum, Canarium strictum, Artocarpus* sp., *Vateria indica* and *Mangifera indica, Diospyros ebenum, Dysoxylum malabarium.* Moist deciduous forests include *Tectona grandis, Dalbergia latifolia, Terminalia tomentosa, Pterocarpus marsupium* and *Bambusa arundinaceam.* In the dry deciduous and thorny types of forests, *Albizia amara, Chloroxylon swietenia* and *Acacia* species are seen.

Soils

They belong to 7 orders, 12 suborders, 27 great groups, 47 subgroups and to 96 soil families. Of the total area of Karnataka, 27% is covered with Alfisols, 25% by Inceptisols, 16% by Entisols, 15% by Vertisols, 8% by Ultisols, 5% by Aridisols

and 1% by Mollisols. And about 4% includes rocky lands, water-bodies and urban area (Reddy *et al.,* 1998).

Land Use

About 54% of the area of the state is under cultivation (of which 13% is irrigated); 16% is under forests, and the remaining 30% is either left barren or is unculturable/culturable waste.

Rainfed crops, sorghum, fingermillet, cotton, groundnut and pulses constitute the major crops. And irrigated crops are paddy and sugarcane. Of the total cropped area, cereals and pulses account for 67%, and the remaining area is under oilseeds, plantation crops, fibre crops and fodder crops. Coconut, coffee, arecanut and cashew are important plantation crops.

Degraded and Wastelands

Degraded and wastelands in the state cover 8,093 thousand ha (about 42% of the TGA). Highly degraded districts are Belgaum (805 thousand ha), followed by Gulbarga (573 thousand ha), Bijapur (508 thousand ha), Koppal (487 thousand ha) and Bagalkot (453 thousand ha) (Fig. 37; Table 38).

About 41% of the total area is affected by water erosion. The affected districts are: Belgaum (795 thousand ha), Gulbarga (567 thousand ha), Bijapur (483 thousand ha), Koppal (478 thousand ha) and Bellary (359 thousand ha). Total acid soils in the state cover 93 thousand ha, the prominent districts are Udupi (38 thousand ha), Uttar Kannada (30 thousand ha) and Dakshin Kannada (22 thousand ha).

Sodicity affected areas are about 145 thousand ha and highest ranking district is Chitradurga (50 thousand ha), followed by Bellary (16 thousand ha) and Mysore (14 thousand ha).

Kerala

Location

It is situated between 8°18′ to 12°48′ N latitudes and 74°52′ to 77°22′ E longitudes and covers 3.88 M ha (38,863 km^2). The state is bounded by Lakshadweep sea on the west, Karnataka in the north and east and Tamil Nadu in the south and east.

Physiography

The state has been divided into Coastal plains and Hills and Uplands. These are further subdivided into Lowlands, Midlands, Central Sahyadri, the Nilgiri and South Sahyadri. The elevations range from less than 30 m above msl of the Coastal plains to more than 2,000 m above msl of the Hills and Uplands.

Geology

Uplift of the Western Ghats during the Miocene-Pliocene has been reported to be responsible for much of the present-day landscape configuration.

Four major geological formations identified have chronological succession as the crystalline rocks of Archaean age, sedimentary rocks of Tertiary age, laterites capping crystallines and sedimentary rocks, and recent sub-recent sediments in the low-lying areas and valleys.

Climate

It is humid tropical with average annual rainfall of about 3,000 mm; 60% of which is received from the south-west monsoon (June to September) and the rest is from north-east monsoon (October to December).

In the higher ranges, represented by Myladumpara, the mean annual air temperature (20.7°C) is lower than that of other parts (27.1°C at Thiruvananthapuram to 27.8°C at Palakkad). The lowest mean monthly temperature of 19.0°C is at Myladumpara in December. Elsewhere lowest temperature occurs during July and August (25° to 26°C). The highest monthly temperature is recorded at Palakkad (31.0°C in April and May).

Natural Vegetation

Vegetation of Kerala comprises tropical wet evergreen and semi-evergreen (50%), tropical moist deciduous (33%) and tropical dry deciduous (2%) forests, grasslands (2%) and forest plantations (13%).

The tropical evergreen forests consist of black dammar (*Canarium strictum*), locally known as *kunthirikkam*; ironwood tree (*Mesua ferrea*) or *churuli; gurjun* tree (*Dipterocarpus indicus*) or *vella ayani*; *poonspar* tree (*Calophyllum elatum*) or *kattu punna*; wild durian (*Cullenia excelsa*) or *vedipla*; Indian *guttarpercha* tree (*Palaquium ellipticum*) or *pali*; white dammar or Indian copal tree (*Vateria indica*) or payini. Many species of bamboo are also found.

Moist deciduous type consists of teak (*Tectona grandis*), *sain* tree (*Terminalia tomentosa*) or *kari-marudu*; kindal tree (*Terminalia paniculata*) or *vellamarudu*; Indian rosewood (*Dalbergia latifolia*) or *weeti*; white teak (*Lagerstroemia lanceolata*) or *venthekku; pyinkado* tree (*Xylia xylocarpa*) or *irul* and Malabar kino tree (*Pterocarpus marsupium*) or *venga*.

Soils

They belong to 5 orders, 10 suborders, 19 great groups, 29 subgroups, and 38 family associations. Ultisols dominate, covering 54%, followed by Inceptisols (30%), Entisols (6%), Alfisols (1%), and Mollisols (1%).

Prominent great groups are: Kandihumults, Kanhaplohumults, Palehumults,

Haplohumults, Kandiustults, Kanhaplustults, Haplustults, Argiustolls, Haplustolls, Rhodustalfs, Haplustalfs, Tropaquepts, Haumutropepts, Ustropepts, Dystropepts, Sulfaquents, Ustipsamments, Ustifluvents and Ustorthents (Krishnan *et al.,* 1996).

Land Use

Kerala has cropping intensity of nearly 134%. In the lowlands of the coastal plains mainly paddy, coconut and banana are grown. In midlands, coconut, tapioca, rubber, arecanut, pepper and cashew are planted with paddy being the main crop in the valleys.

Major part of the hills and uplands region are covered with forests. Small areas are used for growing cardamom, pepper and other spices.

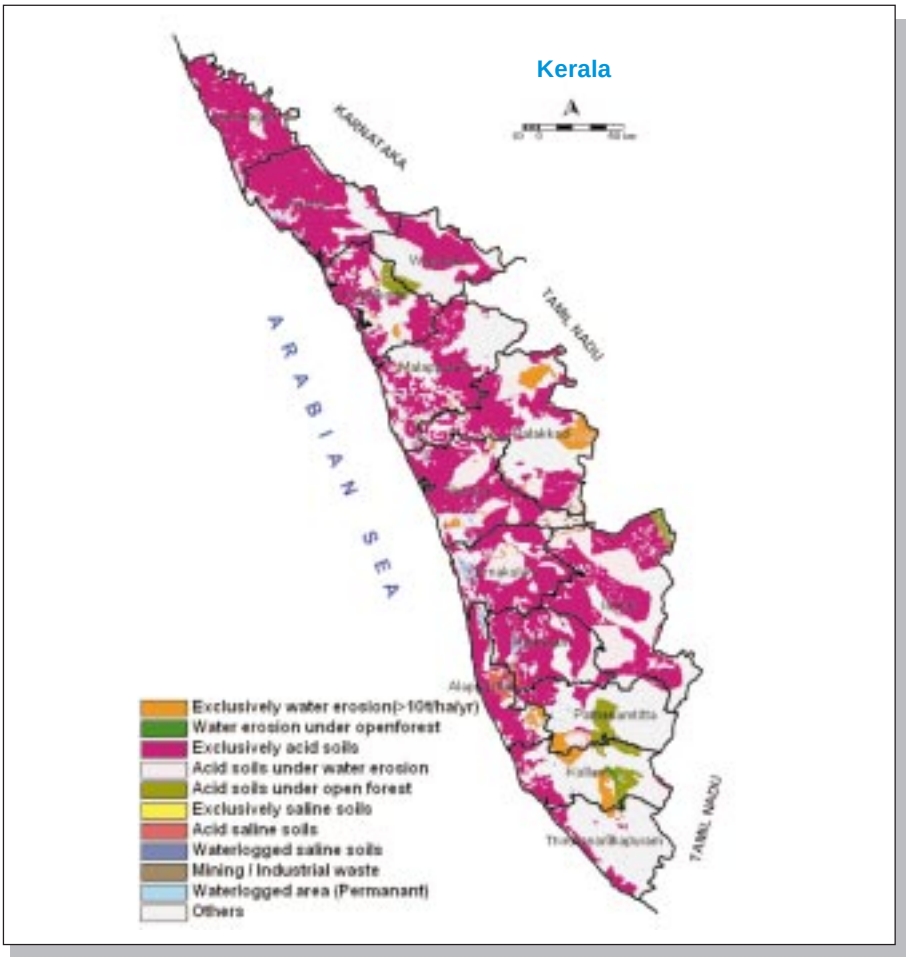

Fig. 38. Degraded and wastelands of Kerala
Source: NBSS&LUP

Table 39. Degraded and wastelands statistics of Kerala (Area in '000 ha)

Districts (14)	Degraded and wastelands classes*											Others**	Total
	1	2	3	4	5	7	9	12	18	19	20		
Alappuzha	8	0	84	4	0	1	15	0	1	6	119	27	146
Ernakulam	2	0	185	51	0	0	0	0	0	10	248	50	298
Idukki	2	0	238	89	8	0	0	0	0	0	337	112	449
Kannur	0	0	234	0	0	0	0	0	0	3	237	63	300
Kasaragod	0	0	174	10	0	0	0	0	0	0	184	19	203
Kollam	24	4	43	3	30	0	0	0	0	2	106	137	243
Kottayam	0	0	155	19	0	0	5	0	0	7	186	38	224
Kozhikode	5	0	131	23	15	0	0	0	0	3	177	59	236
Malappuram	3	0	175	5	0	0	0	0	0	3	186	166	352
Palakkad	45	0	184	41	0	0	0	0	0	0	270	175	445
Pathanamtitta	12	0	44	11	26	0	0	0	0	3	96	161	257
Thiruvananthapuram	3	1	32	2	1	0	0	1	0	0	40	172	212
Thrissur	8	0	185	81	0	0	0	0	0	6	280	28	308
Wayanad	0	0	97	39	7	0	0	0		0	143	70	213
Total	112	5	1,961	378	87	1	20	1	1	43	2,609	1,277	3,886

Notes: Classes*: **1** Exclusively water erosion (>10 tonnes/ha/yr); **2** Water erosion under open forest; **3** Exclusively acid soils; **4** Acid soils under water erosion; **5** Acid soils under open forest; **7** Exclusively saline soils; **9** Acid saline soils; **12** Waterlogged saline soils; **18** Mining/Industrial waste; **19** Waterlogged area (Permanent) Others**: Normal agricultural lands, water-bodies, rivers, lakes and habitats etc. (based on the limited reconnaisance survey)
Source: NBSS&LUP

Degraded and Wastelands

In the state, degraded and wastelands are 2,609 thousand ha (about 67% of the TGA) (Fig. 38; Table 39). Highly degraded districts are Idukki (337 thousand ha), Thrissur (280 thousand ha), Palakkad (270 thousand ha), Ernakulam (248 thousand ha), and Kannur (237 thousand ha). And water erosion accounts for 117 thousand ha (Fig. 38; Table 39).

In total, acidic soils cover 2,426 thousand ha (62% of TGA of the state). The worst affected districts are Idukki (335 thousand ha), followed by Thrissur (266 thousand ha), Ernakulam (236 thousand ha) and Kannur (234 thousand ha). Marshy and waterlogged areas cover about 43 thousand ha. These soils are, however, not depicted in the map due to scale limitation. This state also has the unique acid sulphate soils, covering 20 thousand ha.

Tamil Nadu

Location

Tamil Nadu is situated between 8°05′ to 13°34′ N latitudes and 76°14′ to 80°21′ E longitudes. It covers 13.0 M ha. It is bounded by Karnataka in the north-

west, Andhra Pradesh in the north, Puducherry and Bay of Bengal in the east, Indian Ocean in the south and Kerala in the west and south-west.

Physiography

The state has been divided into Deccan plateau, Hill ranges and Coastal plains. These are further subdivided into ten landforms: South Deccan plateau, Eastern Ghats (South), Tamil Nadu uplands, Nilgiris, South Sahyadri, Marine landform, Riverine landform, Laterite landform, Inland plains, and Kerala plains.

The South Deccan plateau covers about 130 km^2 in the north-western corner of Dharmapuri district. The Eastern Ghats (South) are dissected into isolated hill ranges, running generally north-east-south-west through the northern parts of North Arcot, Ambedkar, Dharmapuri and Periyar. Elevation ranges from 1,100 to 1,600 m above msl. This landform includes Bargur, Kolli, Kalrayan, Shervaroy and Javadi hills.

Geology

Strategraphic succession of rocks occurring in Tamil Nadu shows the Archaean group as the oldest, followed by Mesozoic, Tertiary and Quaternary formations. The Archaean group includes gneisses, charnockites, khondalites and schists. The Mesozoic rocks of Tamil Nadu occur in isolated patches along the eastern coast. The Miocene rocks are (tertiary group) closely associated and are continuous with the Cretaceous rocks of the state. The Pleistocene and recent formations (Quartery group) are laterites and alluvium of marine and riverine origin.

Climate

It is semi-arid tropical monsoonic with an annual rainfall ranging from 550 mm in the plains to 2,400 mm in the hills. Rainfall is received in three distinct seasons—namely south-west monsoon (June to September), north-east monsoon (October to December), and summer and hot weather season (April to May). Major portion of the rainfall is received during the north-east monsoon. Climatic data have shown that potential evapotranspiration exceeds rainfall in most of the areas, excepting Nilgiris and Kodaikanal.

Natural Vegetation

The vegetation of the state comprises tropical wet evergreen and semi-evergreen (50%), tropical moist deciduous (33%) and tropical dry deciduous (2%) forests, grasslands (2%) and forest plantations (13%).

The tropical evergreen forests consist of black dammar (*Canarium strictum*),

locally known as *kunthirikkam*; ironwood tree (*Mesua ferrea*) or *churuli*; *gurjun* tree (*Dipterocarpus indicus*) or *vella ayani*; *poonspar* tree (*Calophylloum elatum*) or *kattu punna*; wild durian (*Cullenia excels*) or *vedipla*; Indian guttarpercha tree (*Palaquium ellipticum*) or *pali*; white dammar or Indian copal tree (*Vateria indica*) or *payini*. Many species of bamboo are also found.

Moist deciduous types consist of teak (*Tectona grandis*), *sain* tree (*Terminalia tomentosa*) or *kari-marudu; kindal* tree (*Terminalia paniculata*) or *vellamarudu*; Indian rosewood (*Dalbergia latifolia*) or *weeti*; white teak (*Lagerstroemia lanceolata*) or *venthekku ;pyinkado* tree (*Xylia xylocarpa*) or *irul*, and Malabar kino tree (*Pterocarpus marsupium*) or *venga.*

Soils

The soils are classified into 6 orders (Entisols, Inceptisols, Alfisols, Mollisols, Ultisols and Vertisols), 12 suborders, 20 great groups, 44 subgroups and 94 soil families. Of the total area of the state, about 50% is covered by Inceptisols, 30%

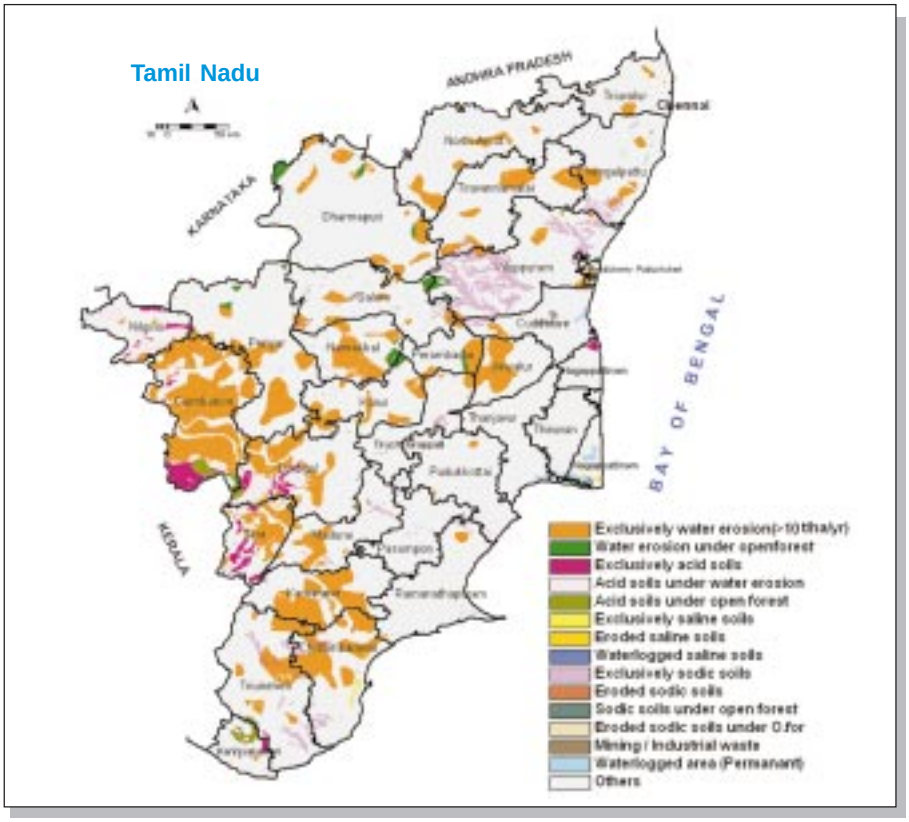

Fig. 39. Degraded and wastelands of Tamil Nadu
Source: NBSS&LUP

Table 40. Districtwise degraded and wastelands statistics of Tamil Nadu (Area in '000 ha)

Districts (29)	Degraded and wastelands classes*														Others**	Total
	1	2	3	4	5	7	8	12	13	14	16	17	18	19	Total of classes		
Ariyalur	72	0	0	0	0	0	0	0	0	0	0	0	1	0	73	122	195
Chengalpattu	43	0	0	0	0	0	0	0	19	3	0	0	2	2	69	374	443
Chidambaranar	150	0	0	0	0	6	1	0	16	5	0	0	1	0	179	283	462
Coimbatore	471	1	56	48	22	0	0	0	0	0	0	0	4	0	602	157	759
Cuddalore	15	0	1	0	0	0	0	0	11	0	0	0	7	6	40	322	362
Dharmapuri	87	23	0	0	0	0	0	0	1	0	0	0	0	0	111	849	960
Dindigul	150	1	30	69	8	0	0	0	0	0	0	0	0	0	258	348	606
Kamarajar	170	0	0	0	0	0	0	0	1	1	0	0	1	0	173	260	433
Kanyakumari	2	0	7	0	17	0	0	0	0	0	0	0	0	0	26	141	167
Karur	62	5	0	0	0	0	0	0	0	0	0	0	1	0	68	233	301
Madurai	55	0	0	0	0	0	0	0	10	0	1	0	0	0	66	283	349
Nagappa-ttinam	0	0	7	0	0	4	0	2	0	0	0	0	0	16	29	237	266
Namakkal	110	11	0	0	0	0	0	0	0	0	0	0	4	0	125	220	345
Nilgiris	13	0	18	79	0	0	0	0	0	0	0	0	0	0	110	142	252
North Arcot	58	0	0	0	0	0	0	0	0	0	0	0	0	0	58	547	605
Pasumpon	0	0	0	0	0	0	0	0	1	0	2	0	0	4	7	409	416
Perambadur	43	6	0	0	0	0	0	0	0	0	0	0	0	0	49	127	176
Periyar	148	8	1	0	0	0	0	0	0	0	0	0	1	0	158	663	821
Pudukkottai	5	0	0	0	0	0	0	0	2	0	0	0	0	0	7	455	462
Ramanatha-puram	10	0	0	0	0	0	0	0	3	0	1	0	0	2	16	394	410
Salem	47	9	0	0	0	0	0	0	4	2	6	0	9	0	77	447	524
Teni	113	0	38	20	0	0	0	0	0	0	0	0	0	0	171	138	309
Thanjavur	0	0	0	0	0	0	0	0	0	0	0	0	0	4	4	333	337
Thiruvan	0	0	0	0	0	0	0	0	2	0	0	0	0	3	5	209	214
Tiruchchirappalli	34	0	0	0	0	0	0	0	20	0	0	0	1	0	55	622	677
Tiruvannamalai	66	0	0	0	0	0	0	0	4	3	0	0	0	0	73	389	462
Triunelveli	96	0	3	0	3	0	0	0	31	9	0	0	1	0	143	477	620
Triuvalur	16	0	0	0	0	0	0	0	0	0	0	0	1	0	17	323	340
Viluppuram	27	7	0	0	0	0	0	0	180	5	7	2	0	0	228	504	732
Total	2,063	71	161	216	50	10	1	2	305	28	17	2	34	37	2,997	10,008	13,005

Notes: Classes*: **1** Exclusively water erosion (>10 tonnes/ha/yr); **2** Water erosion under open forest; **3** Exclusively acid soils; **4** Acid soils under water erosion; **5** Acid soils under open forest; **7** Exclusively saline soils; **8** Eroded saline soils; **12** Waterlogged saline soils; **13** Exclusively sodic soils; **14** Eroded sodic soils; **16** Sodic soils under open forest; **17** Eroded sodic soils under open forest; **18** Mining/Industrial waste; **19** Waterlogged area (Permanent)
Others**: Normal agricultural lands, water-bodies, rivers, lakes and habitats etc. (based on the limited reconnaisance survey)
Source: NBSS&LUP

by Alfisols, 7% by Vertisols, 6% by Entisols, 1% by Ultisols, and negligible area by Mollisols (Natarajan *et al.*, 1997).

Land Use

Hilly areas have major portion under forests and natural vegetation cover, and the plains are intensively cultivated. Natural vegetation consists of evergreen, dry deciduous and shrub types. Cultivable lands account for about

50% and forests about 16% of the TGA. Paddy is grown in large areas, followed by groundnut, sugarcane, cotton, pulses and other crops.

Degraded and Wastelands

Degraded and wastelands area of the state totals to 2,997 thousand ha, which is about 23% of TGA. The worst affected districts are Coimbatore (602 thousand ha), Dindigul (258 thousand ha), Viluppuram (228 thousand ha), Chidambaranar (179 thousand ha), Kamarajar (173 thousand ha), Teni (171 thousand ha) and Periyar (158 thousand ha) (Fig. 39; Table 40).

Water erosion, major causative factor for land degradation, has affected 2,134 thousand ha (about 16% of TGA); Coimbatore is worst affected with an area of 472 thousand ha.

Acidic soils cover 427 thousand ha (4% of TGA), and districts affected in order are Coimbatore (126 thousand ha), followed by Dindigul (107 thousand ha), Nilgiris (97 thousand ha) and Teni (58 thousand ha).

Sodic soils occupy an area of 352 thousand ha (3% of TGA) with highest area in Viluppuram (194 thousand ha), followed by Triunelveli (40 thousand ha), Chengalpattu (22 thousand ha) and Chidambaranar (21 thousand ha). Saline soils are found in Chidambaranar (7 thousand ha) and Nagappattinam (6 thousand ha).

9 LAND DEGRADATION SEVERITY RANKINGS FOR DIFFERENT STATES

Among the 19 identified classes of land degradation, water erosion, acid soils, salinity and sodicity are the predominant ones, and occupy larger areas in different states. To plan conservation/ameliorative measures through different agencies, statewise and districtwise statistics of the areas affected by the

Table 41. Statewise ranking of lands degraded by water erosion

State	TGA (km²)	Degraded and wastelands classes* ('000 ha)			Area (%)
		1	2	(1+2)	
Uttar Pradesh	238,566	12,370	514	12,884	54
Madhya Pradesh	308,641	11,881	1,584	13,465	44
Karnataka	191,791	7,450	349	7,799	41
Jharkhand	79,714	2,825	356	3,181	40
Andhra Pradesh	275,045	8,050	814	8,864	32
Meghalaya	22,429	127	579	706	31
Asom	78,438	1,929	437	2,366	30
Maharashtra	307,713	8,400	422	8,822	29
Rajasthan	342,239	7,436	1,196	8,632	25
Orissa	155,707	2,176	1,152	3,328	21
Delhi	1,483	28	0	28	19
Uttarakhand	55,845	829	180	1,009	18
Chhattisgarh	134,805	2,347	75	2,422	18
Himachal Pradesh	55,673	941	43	984	18
Tamil Nadu	130,058	2,063	71	2,134	16
West Bengal	88,752	1,167	97	1,264	14
Bihar	94,163	820	229	1,049	11
Jammu and Kashmir	222,236	1,327	674	2,001	9
Tripura	10,486	26	48	74	7
Manipur	22,327	36	114	150	7
Haryana	44,212	303	0	303	7
Punjab	50,362	228	74	302	6
Gujarat	196,024	979	32	1,011	5
Arunachal Pradesh	83,743	165	215	380	5
Kerala	38,863	112	5	117	3
Nagaland	16,579	1	30	31	2
Sikkim	7,096	2	0	2	0
Goa	3,702	1	0	1	0
Mizoram	21,081	0	0	0	0
Andaman and Nicobar Islands	8,249	0	0	0	0
Others**	1,248			0	0
Total	3,287,263	74,020	9,290	83,310	

Notes: Classes*: **1** Exclusively water erosion (>10 tonnes/ha/yr); **2** Water erosion under open forest
Others**: Chandigarh, Dadar and Nagar Haveli, Daman and Diu, Lakshadweep and Puducherry
Source: NBSS&LUP

Table 42. Statewise ranking of acid soils

State	TGA (km^2)	Degraded and wastelands classes* ('000 ha)				Area (%)
		3	4	5	(3+4+5)	
Nagaland	16,579	17	45	1454	1,516	91
Manipur	22,327	115	86	1396	1,597	72
Tripura	10,486	101	83	525	709	67
Kerala	38,863	1,961	378	87	2,426	62
Mizoram	21,081	150	0	1013	1,163	55
Meghalaya	22,429	52	175	796	1,023	46
Goa	3,702	103	0	0	103	28
Asom	78,438	411	1,319	265	1,995	25
Arunachal Pradesh	83,743	300	501	968	1,769	21
Chhattisgarh	134,805	812	1,383	147	2,342	17
Jharkhand	79,714	226	394	115	735	9
Sikkim	7,096	2	43	13	58	8
Uttarakhand	55,845	13	189	198	401	7
West Bengal	88,752	240	165	13	418	5
Tamil Nadu	130,058	161	216	50	427	3
Madhya Pradesh	308,641	121	332	29	482	2
Orissa	155,707	107	51	45	203	1
Himachal Pradesh	55,673	34	41	1	76	1
Maharashtra	307,713	41	228	0	269	1
Karnataka	191,791	69	24	0	93	1
Bihar	94,163	19	22	0	41	0
Jammu and Kashmir	222,236	21	42	15	78	0
Haryana	44,212	2	0	0	2	0
Andhra Pradesh	275,045	1	0	0	1	0
Punjab	50,362	0	0	0	0	0
Andaman and Nicobar Islands	8,249	0	0	0	0	0
Delhi	1,483	0	0	0	0	0
Gujarat	196,024	0	0	0	0	0
Rajasthan	342,239	0	0	0	0	0
Uttar Pradesh	238,566	0	0	0	0	0
Others**	1,241					
Total	3,287,263	5,080	5,720	7,130	17,930	

Notes: Classes*: **3** Exclusively acid soils (pH <5.5); **4** Acid soils under water erosion; **5** Acid soils under open forest
Others**: Chandigarh, Dadar and Nagar Haveli, Daman and Diu, Lakshadweep and Puducherry
Source: NBSS&LUP

prominent degradation classes is a prerequisite. This statistics will also be useful for sanctioning grants to various centrally sponsored schemes by the Government, and will be a guide to donor agencies. Statewise area statistics under four prominent degradation classes has been presented in this Chapter. The rankings are based on the percentage area of the TGA of the affected state.

Water erosion is the most predominant degradation class affecting large number of states. Uttar Pradesh is the worst affected state, covering 54% of the TGA, followed by Madhya Pradesh, Karnataka, Jharkhand, Arunachal Pradesh and Meghalaya, covering 44%, 41%, 40%, 32% and 31% of the TGA (Table 41). Asom, with 30% affected area ranks seventh and Maharashtra with 29% ranks eighth.

The second major degradation class is soil acidity, particularly in soils having *p*H <5.5. Though soils with *p*H 5.5–6.5 qualify for acid soils, their affect on crop productivity is not so severe to rank them as problematic. Many crops grow successfully in this *p*H range. Moreover, soils of the North-Eastern Region within this *p*H range support a luxuriant forest vegetation. Nagaland with 91% of TGA, ranks first among states affected with soil acidity, followed by Manipur (72%). The other states following in order are Tripura, Kerala, Mizoram, Meghalaya, Goa, Asom, Arunachal Pradesh and Chhattisgarh. Jharkhand where research on acid soils has received countrywide recognition, ranks tenth (Table 42). It may be suggested that ameliorative amendments like liming materials need to be supplied on a priority basis to these states.

Table 43. Statewise ranking of saline soils

State	TGA (km²)	Degraded and wastelands classes* ('000 ha)							Area (%)
		7	8	9	10	11	12	(7+8+9+ 10+11+12)	
Andaman and Nicobar Islands	8,249	71	0	0	0	0	0	71	9
Gujarat	196,024	1495	4	0	0	60	0	1,559	8
West Bengal	88,752	408	0	0	0	0	0	408	5
Rajasthan	342,239	74	8	0	110	0	0	192	1
Maharashtra	307,713	164	7	0	0	0	0	171	1
Orissa	155,707	131	0	0	0	0	6	137	1
Kerala	38,863	1	0	20	0	0	0	21	1
Haryana	44,212	44	2	0	0	0	0	46	1
Andhra Pradesh	275,045	56	4	0	0	0	17	77	0
Bihar	94,163	39	1	0	0	0	5	45	0
Uttar Pradesh	238,566	9	13	0	0	0	0	22	0
Tamil Nadu	130,058	10	1	0	0	0	2	13	0
Karnataka	191,791	2	0	0	0	0	0	1	0
Arunachal Pradesh	83,743	0	0	0	0	0	0	0	0
Asom	78,438	0	0	0	0	0	0	0	0
Chhattisgarh	134,805	0	0	0	0	0	0	0	0
Delhi	1,483	0	0	0	0	0	0	0	0
Goa	3,702	0	0	0	0	0	0	0	0
Himachal Pradesh	55,673	0	0	0	0	0	0	0	0
Jammu and Kashmir	222,236	0	0	0	0	0	0	0	0
Jharkhand	79,714	0	0	0	0	0	0	0	0
Madhya Pradesh	308,641	0	0	0	0	0	0	0	0
Manipur	22,327	0	0	0	0	0	0	0	0
Meghalaya	22,429	0	0	0	0	0	0	0	0
Mizoram	21,081	0	0	0	0	0	0	0	0
Nagaland	16,579	0	0	0	0	0	0	0	0
Punjab	50,362	0	0	0	0	0	0	0	0
Sikkim	7,096	0	0	0	0	0	0	0	0
Tripura	10,486	0	0	0	0	0	0	0	0
Uttarakhand	55,845	0	0	0	0	0	0	0	0
Others**	1,241	124	0	0	0	0	0	124	4
Total	3,287,263	2,635	48	29	120	71	42	2,887	

Notes: Classes*: **7** Exclusively saline soils; **8** Eroded saline soils; **9** Acid saline soils; **10** Saline soils under wind erosion; **11** Saline soils under open forest; **12** Waterlogged saline soils
Others**: Chandigarh, Dadar and Nagar Haveli, Daman and Diu, Lakshadweep and Puducherry
Source: NBSS&LUP

Table 44. Statewise ranking of sodic soils

State	TGA (km^2)	Degraded and wastelands classes* ('000 ha)						Area (%)
		13	14	15	16	17	(13+14+ 15+16+ 17)	
Uttar Pradesh	238,566	626	692	0	2	0	1,320	6
Haryana	44,212	183	1	0	0	0	184	4
Punjab	50,362	151	1	0	0	0	152	3
Gujarat	196,024	545	0	0	0	0	545	3
Tamil Nadu	130,058	305	28	0	17	2	352	3
Maharashtra	307,713	256	164	0	0	1	421	1
Andhra Pradesh	275,045	154	39	0	0	1	194	1
Rajasthan	342,239	108	26	30	1	16	181	1
Karnataka	191,791	97	48	0	0	0	145	1
Bihar	94,163	98	8	0	0	0	106	1
Madhya Pradesh	308,641	74	49	0	1	0	124	0
Chhattisgarh	134,805	10	3	0	0	0	13	0
Andaman and Nicobar Islands	8,249	0	0	0	0	0	0	0
Arunachal Pradesh	83,743	0	0	0	0	0	0	0
Asom	78,438	0	0	0	0	0	0	0
Delhi	1,483	0	0	0	0	0	0	0
Goa	3,702	0	0	0	0	0	0	0
Himachal Pradesh	55,673	0	0	0	0	0	0	0
Jammu and Kashmir	222,236	0	0	0	0	0	0	0
Jharkhand	79,714	0	0	0	0	0	0	0
Kerala	38,863	0	0	0	0	0	0	0
Manipur	22,327	0	0	0	0	0	0	0
Meghalaya	22,429	0	0	0	0	0	0	0
Mizoram	21,081	0	0	0	0	0	0	0
Nagaland	16,579	0	0	0	0	0	0	0
Orissa	155,707	0	0	0	0	0	0	0
Sikkim	7,096	0	0	0	0	0	0	0
Tripura	10,486	0	0	0	0	0	0	0
Uttarakhand	55,845	0	0	0	0	0	0	0
West Bengal	88,752	0	0	0	0	0	0	0
Others**	1,241						0	0
Total	3,287,263	2,620	1,073	45	37	20	3,737	

Notes: Classes*: **13** Exclusively sodic soils; **14** Eroded sodic soils; **15** Sodic soils under wind erosion; **16** Sodic soils under open forest; **17** Eroded sodic soils under open forest
Others**: Chandigarh, Dadar and Nagar Haveli, Daman and Diu, Lakshadweep and Puducherry
Source: NBSS&LUP

And soil salinity is another major degradation class affecting mainly coastal states. Salinity is highest in Andaman and Nicobar islands, covering 9% of TGA (Table 43), followed by Gujarat (8%) and West Bengal (5%). Orissa, Rajasthan, Maharashtra and Haryana each has 1% affected area.

Soil sodicity has been found to affect physical and nutritional characteristics of the lands and ultimately rendering them partially or fully non-productive. Sodicity problem is very intensive in Uttar Pradesh, affecting 6% of the TGA, (Table 44), followed by Haryana (4%) and Punjab, Gujarat and Tamil Nadu (3% each). The need for amendments or reclaiming sodic soils is to be prioritized accordingly. Other states of the country are not affected by sodicity.

10 SCIENTIFIC AND TECHNICAL RELEVANCE

The study on the degraded and wastelands of India is focused to understand the relevance of land degradation-based processes on the areal extent, spatial variability, deterioration of land parcels and their unsustainable land use. It has been observed by the researchers that degraded and wastelands have immensely damaged productive lands, water sources and environmental ecosystem. Different developmental agencies faced problems in implementing plans to rehabilitate degraded lands owing to non-consistent area statistics of the wasted lands and also because of incomplete information available on their extent and location. Implementation of developmental plans by the government agencies can be streamlined and better focused by using outputs of this study.

A map on the degraded and wastelands of the country was first prepared on 1:250,000 scale. It showed nature and spatial distribution of different classes and types of degraded and wastelands. Based on this map, the area statistics at the national, state and district levels has been generated. A strong geo-spatial database having attribute datasets and spatial layers was placed in the National Soil Resource Information Centre (NASRIC) of the NBSS&LUP, Nagpur, in the georeferenced environment. The baseline data generated for this study will be highly useful for further refinement of the datasets at a larger scale (e.g. at 1 : 50,000 scale), as is being presently attempted by the NRSA (Now NRSC). It will also help to enrich the national natural resource database, being organized by the National Natural Resource Management System, Natural Resource Database Management System, National Spatial Data Infrastructure and Indian National Agricultural Resource Information System and others.

This study is of international relevance since it can contribute to the global research agenda operative in India on the implementation of the conservation agriculture and preservation of our natural resources and environment.

Technological Relevance

The technological aspects of this study have emphasized on the development of a methodology for the harmonization of different datasets using advanced tools like remote sensing and GIS, and have provided one-stop-

solution for the estimation of the degraded and wastelands of the country. The results would also help stymie duplication of research and development efforts on the degraded lands and avoid contradictory results. It will also help in assessing and matching various classes and types of degraded and wastelands to an agreeable terminology and a nomenclature for the introduction of sustainable land use for increased agricultural productivity and land-water conservation. GIS-based methodology has its uniqueness in removing duplication in the calculation of the areas exposed to more than one type of degradational processes and also of class mismatch. This methodology can also be utilized as a benchmark procedure for further refinement and rectification of the database on the land resources.

The principal findings emerging out of the study are that the degraded and wastelands in the country cover 120.4 M ha, incorporating combination of various wasteland classes and degraded lands. This data has been supported with the results from other studies like soil salinity mapping, soil loss assessment of different states of India, wind erosion and assessment of acid soils in India, along with the data derived from the wasteland mapping project of the NRSC. The datasets provide a new dimension towards attempting rehabilitation of problematic lands of India, and a solution has been advanced to the conflicting databases generated earlier by the different agencies.

Glaciers and rock outcrops are not considered degraded and wastelands since glaciers contribute to water resources and rock outcrops are of economic value.

The study has significant relevance to the impacts of climate change on the hydrological cycle, severity of floods and droughts, coastal zones, biodiversity and aquatic life. The extent, type and severity of degradation can be used as indicators in climate change research and for the introduction of the conservation-effective sustainable agrotechnologies.

Socio-economic Relevance

It is now well-recognized that in Asia, poverty has been mainly a rural phenomenon, where nearly three-fourth of the poor food-insecure live and are dependent on the natural resources for employment and income. South Asia has a poverty incidence of 43% (or about 520 million people), and only here 40% of the world's poor reside. Also, severely degraded lands are mostly inhabited by marginal farmers and tribal populations, who are poor and less literate. These people are devoid of land-based amenities and infrastructure in comparison with the farmers who cultivate better lands (Chaturvedi and Thayalan, 2003; Chaturvedi 2010). FAO-led studies have also concluded that soil erosion and

other land-degradation processes have led to nutrient depletion thus reducing soil quality. A vicious cycle of poverty and subsistence agro-production is the core cause of the endemic rural poverty. Poverty and natural resources degradation coerces individuals to greed and in the search of more land for food. People are thus driven to convert forests to farms, cultivate steep slopes and degrade further marginal lands. Conservation of natural resources and rejuvenation of the degraded and wastelands, therefore, offer potentially enormous means of poverty alleviation and sustainable livelihood (Srivastava *et al.* 2002).

A set of 100 districts have been identified by the Planning Commission of India as the most backward. These are geographically concentrated in the regions with either inhospitable terrain and/or are identified as degraded lands. These are also food-insecure districts. Over-exploitation of land resources is going to be even more severe in these districts in the coming years owing to the need to produce more food. Studies have been carried out to examine implications of land degradation in terms of the resulting economic losses. The total economic losses to the country at current prices have been estimated to be a staggering sum of over Rs 285,000 million, which is about 12% loss as per the total value productivity of these lands (Vasisht *et al.* 2003).

The reclamation procedures to be opted for the rehabilitation of the degraded lands will have a significant impact on the socio-economic development of the country. The output of this study indicates quantum of degraded and wastelands in the spatial domain, that can be used for formulating and implementing different government—NGO sponsored programmes in the public-private partnership mode towards rural employment generation and also for providing food security in these marginal regions.

Public Sector Relevance

The generation of the harmonized data and information on the status, extent and spatial distribution of the degraded lands and wastelands in the GIS-compatible environment is a national priority for developmental planning of the country. The Sub-Group V of the Planning Commission on the Natural Resource Management has emphasized that high priority needs to be given for generating such information. The results of this study will be of immense value for the following national organizations: (1) Planning Commission, Government of India; (2) Ministry of Agriculture, Government of India; (3) Ministry of Environment and Forests, Government of India; (4) Ministry of Rural Development, Government of India; (5) Ministry of Science and Technology, Government of India; (6) Ministry of Water Resources, Government of India;

(7) National Wasteland Development Board, Govt of India; (8) Indian Council of Agricultural Research; and (9) National Rainfed Area Authority, among others. Similarly, the National Natural Resources Management System (NNRMS, DOS) and the ISRO can use datasets with the information gathered by space observations. Non-Governmental Organizations (NGOs) can also plan their developmental activities for upgrading land quality and for framing suitable policies to enhance production, productivity, profitability and sustainability of the degraded and wastelands.

The Department of Agriculture and Co-operation has emphasized on the assessment of the status of the degraded and wastelands and implementation of the programmes/schemes for their reclamation and development. Emphasis has also been given to watershed development in shifting cultivation areas through special central assistance in the state plan schemes. Similarly, centrally sponsored programmes of the soil conservation in the catchments of river valleys, flood-prone areas and reclamation and development of alkali and acidic soils can be benefited by the outcomes of this study. The Planning Commission can employ district-level data given here for formulating strategies at the micro-level and can initiate actions on the remedial measures to be taken to restore degraded and wastelands for better land-use, for saving agricultural lands from deterioration, for pre-urban agricultural development and planned development of industrial sector and habitation and settlements. The datasets derived would be useful to combat problems of denudation of forests, silting of water-bodies, dams and reservoirs, depletion and pollution of groundwater resources, global warming and declining soil health. The datasets can be effectively used for management of floods and droughts.

The programmes executed by the Ministry of Rural Development incorporate several developmental works in the remote rural countryside where degraded and wastelands occur in abundance. These programmes of the Ministry can be directed to areas that are mapped as potentially degraded and are wasted lands. Since this study has broadly identified constraints and the basic causes of land degradation, the programmes related to forestry and agroforestry can be ventured to arrest land degradation on the one hand, and sustain environment on the other. Such interventions will also help slow down of global warming and climate change.

The Perspective Plan of the National Rainfed Area Authority emphasizes on the issues related to land resource inventory and mapping of degradation/desertification in the country. Different developmental plans from national to local levels can be taken up by judging status and extent of degraded and wastelands of the respective areas.

The Ministry of Environment and Forests has a very crucial and important role in the maintenance of the national environmental quality and forest related issues; the degradation of land resources directly relates to environment. With varying terrain and climatic characters of the country, the problems are also very location-specific in nature. The information on the status and mapping of the types of degraded lands will give a clue to environmentalists for the development of location-specific strategies to preserve quality of the environment.

The National Wasteland Development Board (earlier under the Ministry of Environment and Forests) is a nodal agency for combating problems of land degradation and restoration of ecology. Presently, the department under the Ministry of Rural Areas and Employment has been mainly responsible for reclaiming wastelands in the non-forest areas, where government acts as a facilitator and rural people as executors of the programme. The major programmes are implemented for improving productivity of degraded and wastelands keeping in view poverty, backwardness, gender and equity issues. The datasets generated would help the department in implementing various projects undertaken by them in the targeted regions. Thus activities like *in-situ* soil-and-moisture conservation, bunding, terracing, trenching, drainage treatment, agroforestry and vegetative barrier, floral generation and natural regeneration of biota can be planned based on the knowledge on the extent of degraded and wastelands in the areas of their operation.

The Indian Council of Agricultural Research, in general, and the Natural Resource Management Division, in particular, will be benefited by the results of this study in drawing up research agenda for the natural resource conservation and management, water harvesting site selection, agroforestry planning, soil-and-water conservation, and terrain and geomorphological research can well be formulated based on the information available from the maps and datasets. Research activities pertaining to climate change, organic carbon sequestration for enhancing carbon stocks in the soils can draw upon the data on the degraded and wastelands.

Besides the above, the concerned line-departments at the state level can also utilize outcomes of this study, while implementing their local developmental plans. The maps of the states and the data on the degraded and wastelands and their constraints would help in formulating activities pertaining to soil conservation, water resource management, site selection for water harvesting, wasteland development, reclamation and remediation of degraded lands to bring them under the plough through development and application of new agrotechnologies. The results will also help in the identification of areas

for rural employment generation, addressing problems of food insecurity, forest and agroforestry planning, bio-fuel production, water resource management in the rainfed areas and for environmental protection and its security.

The databases contained in this study are given in the GIS-platform. These can be used for undergirding several information systems on the status of the natural resources such as the database of the National Natural Resource Management System (NNRMS) of the ISRO, Natural Resource Database Management System (NRDMS) and the National Spatial Data Infrastructure (NSDI) of the DST, and the Indian National Agricultural Resource Information System (INARIS) of the ICAR. These can be enriched with the addition of this important spatial database.

Land degradation and data on the wastelands can also be used as an effective indicator in the climate change studies at the regional and global scales. The global research organization like the CGIAR, FAO and others dealing with the natural resources management and food security would get a new dimension on the degraded and wastelands of India. This study would definitely help to refine estimates of degraded lands in the Asian region by the FAO. Global database like ISRIC and SOTER will also be enriched.

The outcomes once placed on the platform of the 'Open GIS System', would provide scope for better refinement and would enrich data used by different stakeholders' working group at the global, regional and local levels for calculating carrying capacity of the lands at various scales.

11 POINTS TO PONDER: WAY FORWARD

In the population-rich countries with finite land resources, agricultural natural resource security is of utmost importance. Further, because the crop yields and productivity of the 'favoured agricultural regions' have platued out, it is essential that the degraded and wastelands are rehabilitated and rejuvenated so that such lands are rendered cultivable and may become effective in supporting food crop production, agroforestry and forestry-based land-use systems. Further, global environmental change and variability are forcing irreparable damage to the arable lands adjoining degraded lands, water and biodiversity resources. These would have serious consequences on food production and food security in the coming years.

This study on the degraded and wastelands of India in a way contains the first approximation of the harmonized results of the inter-institutional effort. Several points of immediate application are indicated. These are detailed as follows.

- Planning for land conservation should be prioritized based on the severity of the degradational problems arising owing to water and wind erosions and anthropogenic activities. Afforestation activities like agroforestry, silviculture and social forestry should be adopted to protect agricultural lands from further deterioration arising out of degradational processes. Afforestation of degraded and wastelands should be given priority.
- As conservation and land rehabilitation measures are highly expensive, the area for reclamation should be prioritized based on the severity of the land degradation, the nature of the extent of the problem and the proposed land use. The maps and the data given in this publication can be effectively used for such initiatives.
- Reclamation of acidic, saline and sodic soils should get priority in the districts that are severally affected by them in different states. These are chemical land degradational processes and materials needed for their amelioration and reclamation are easily available. The materials should be made available in a planned manner in accordance with the severity of the problem prevailing in the districts/states.

- Where complex problems of degradation like water erosion, acidity and water erosion, salinity and sodicity co-exist, the research agenda needs to be reoriented to bring out a list of "good practices" for amelioration of soil health of such degraded lands.
- Cultivation of bio-fuel producing plants and fuel trees/crops should be encouraged in the degraded and wastelands. This is an essential step for environmental protection. The datasets and maps of this study can help district authorities to plan activities accordingly.
- Minerals and mining explorations should be taken up in degraded areas (comparing the present maps with the maps of Geological Survey of India) to protect good lands from deterioration. Wastelands due to mining should be reclaimed with suitable technologies, and appropriate land-use plans may be drawn up for better utilization of such landscapes.
- The district-level data produced on degraded and wastelands should be effectively used to prioritize areas for reclamation, water harvesting, etc. through different rural employment generation schemes at the local level. State- and district-level authorities should be trained to utilize information given in this publication to operationally develop and implement activities at the state and district levels for rural development.

Impacts

- The outcomes of this study, once adopted by different agencies, would provide impetus in improving health of land resources through the adoption of recommended practices. This way an appreciable area of degraded lands can be brought under cultivation through reclamation processes in different problematic soils, which, in turn, will enhance production and productivity of various commodities, and safeguard further deterioration of lands.
- The acute problem of water shortage in the country, particularly in the rainfed areas, can be appreciably mitigated by employing special package of practices on the land parcels having problems related to land degradation; identified by this study.
- The output of the harmonized area statistics and maps of the degraded and wastelands can be utilized in programmes related to land development under different schemes run by Government of India to uplift rural communities. This will also enhance livelihood security by generating additional financial resources and reducing food insecurity of the rural people by providing suitable land-based jobs, and finally.

- The database and GIS-based maps generated in the study can be used most effectively by the National and State Planning Commissions/ departments to assign high priority to areas identified as degraded and wastelands, where public investments would yield benefits for the welfare of the people of the country and also for the security of the food and environment in the future.

ANNEXURES

Annexure -1

Agroecological regions, their climate and forest types of India

Region No.	Agroecological regions	Climate	Forest type
1	Western Himalayas Cold Arid Ecoregion	Cold arid	Snow covered most of the time
2	Western Plains Hot Arid Ecoregion	Hot arid	Tropical thorn forest - 6
3	Deccan Plateau Hot Arid Ecoregion	Hot arid	Tropical thorn forest - 6
4	Northern Plains and Central Highlands Ecoregion	Hot semi-arid	Tropical dry deciduous forest - 5 Tropical thorn forest - 6
5	Central (Malwa) Highlands, Gujarat Plains and Kathiawar Peninsula Ecoregion	Hot semi-arid	Dry deciduous forest - 5
6	Deccan Plateau, Hot Semi-arid Ecoregion	Hot semi-arid	Tropical dry deciduous forest- 5 Tropical thorn forest - 6
7	Deccan (Telangana) Plateau and Eastern Ghats, Hot Arid Ecoregion	Hot semi-arid	Tropical dry deciduous forest- 5 Tropical thorn forest - -6
8	Eastern Ghats, Tamil Nadu Uplands and Deccan (Karnataka) Plateau, Hot Semi-arid Ecoregion	Hot, semi-arid	Tropical dry deciduous forest- 5 Tropical thorn forest - 6
9	Northern Plain, Hot Subhumid (Dry) Ecoregion	Hot subhumid (dry)	Tropical moist deciduous forest- 3 Tropical dry deciduous forest - 5
10	Central Highlands (Malwa, Bundelkhand and Eastern Satpura Range), Hot Subhumid (Dry/Moist) Ecoregion	Hot subhumid (dry)	Tropical dry deciduous forest - 5 Tropical moist deciduous forest - 3
11	Chhattisgarh/ Mahanadi Basin Hot Moist/ Dry Subhumid Ecoregion	Hot moist/dry subhumid	Tropical moist deciduous forest - 3
12	Eastern (Chhotanagpur) Plateau and Eastern Ghats, Hot Subhumid Ecoregion	Hot subhumid	Tropical dry deciduous forest - 5 Tropical moist deciduous forest - 3
13	Eastern Plains, Hot Subhumid (Moist) Ecoregion	Hot subhumid (moist)	Tropical moist deciduous forest- 3 Tropical dry deciduous forest - 5
14	Western Himalayas, Warm, Moist Semi-arid to Dry Subhumid Ecoregion	Warm subhumid (to humid with inclusion of per humid)	Moist temperate - 11 Subtropical pine - 9 Sub-alpine forest-14
15	Bengal and Asom Plains, Hot Subhumid (Moist) to Humid (inclusion of Per-humid) Ecoregion	Hot per-humid	Tropical moist deciduous forest- 3 Tropical dry deciduous forest - 5
16	Eastern Himalayas, Warm Per-humid Ecoregion	Warm per-humid	Subtropical pine-9 Wet temperate-12 Wet evergreen—1 Subalpine forest-14
17	North Eastern Hills (Purvanchal), Warm Per-humid Ecoregion	Warm per-humid	Wet evergreen-1 Tropical moist deciduous forest-3 Wet temperate forest-12
18	Eastern Coastal Plains, Hot Subhumid to Semi-arid Ecoregion	Hot subhumid	Littoral and swamp forest-4
19	Western Ghats and Coastal Plains, Hot, humid-Perhumid Ecoregion	Hot humid Per-humid	Tropical moist deciduous forest-3
20	Islands of Andaman-Nicobar and Lakshadweep, Hot, Humid to Per-humid Islands Ecoregion	Hot per-humid	Tropical wet evergreen-1 Littoral swamp forest-4

Source: Pathak *et al.* 2009.

Annexure-2

Forests types of India and major species components

Forest type, area, and % of total	Rainfall (mm)	Area	Major species components
1. Tropical wet evergreen forests 4.5 M ha, 5.8%	More than 2,500	Western Ghats in A&N Islands, upper Asom Region, Arunachal Pradesh	Malayan affinity. Many tiered formation of multitude of evergreen species but with no bamboos except *Ochlandra,Dipterocarpus indicus, Vateria indica, Palaquium ellipticum* of Western Ghats, *Dipterocarpus turbinatus, Hopea odorata* of A&N Islands (*Terminalia* spp.) *Artocarpus chaplasa* in Asom
2. Tropical semi-evergreen type 1.9 M ha, 2.5%	Over 1,500	Strip of West Coast, Andaman and Nicobar Islands, Asom, West Bengal, Orissa region	West Coast- *Vateria indica, Hopea parviflora, Xylia xylocarpa;* NEH region- *Shorea robusta, Michelia champaca, Schima wallichii, Gmelina arborea, Cedrela toona.* Bamboo are common *Dendrocalamus hamiltonii* in West Bengal and parts of Asom; *Melocanna bambusoides* in eastern Asom;*Bambusa arundinacea* in Orissa; *Ochlandra* species and *B. arundinacea* in West Coast
3. Tropical moist deciduous type 23.3 M ha, 30.3%	1,500–2,000 with a dry season of 4–6 months	Orissa (Puri), Bihar, West Bengal, Asom, Western Ghats, Andhra Pradesh, Maharashtra	Dominant species are deciduous. The evergreen habit is in the lower storey. Bamboos are characteristics of this group.Many tree species of secondary importance are *Terminalia tomentosa, T. belerica, Dillenia pentagyna, Madhuca indica.* Dominant species are: *sal* in Orissa(Puri), Bihar (Singhbhum) West Bengal (Buxa), Asom (Kamrup), teak, *Pterocarpus marsupium* and *Dalbergia latifolia* in south, *T. binata. T. manii* in Andaman and Nicobar Islands
4. Littoral and swamp forests 0.7 M ha, 0.9%		Delta of Ganga and Brahmputra, coast of Andaman and Nicobar Islands, Uttar Pradesh, West Bengal, Asom (freshwater swamp)	*Heritiera, Bruguiera, Rhizophora, Ceriops, Avicennia,Barringtonia* spp., *Syzygium cumini, Dillenia, Barringtonia acutangula, Terminalia arjuna, Lagerstroemia speceosa, Trewia nudiflora, Myristica* spp.

Forest type, area, and % of total	Rainfall (mm)	Area	Major species components
5. Tropical dry deciduous forests, 29.4 M ha, 38.4%	750-1,250	From Kanyakumari to foot hills of Himalaya, around rivers of Ganga, Narmada, Tapti	These forests consist of trees having height less than 25 m. Some important species are: *Tectona grandis*, *sal, sandal Pterocarpus santalinus*, *Hardwickia binata, Butea monosperma, Terminalia tomentosa, Boswellia serrata, Acacia catechu, Anogeissus pendula, Dendrocalamus strictus*
6. Tropical thorn forests, 5.2 M ha, 6.7%	250–750	Rajasthan, Punjab, western Uttar Pradesh, Gujarat and Central Dry Peninsula	*Prosopis cineraria, Acacia nilotica, A. leucophloea, A. catechu,Prosopis juliflora, Euphorbia, Zizyphus, Mimosa, Aegle, Capparis, Dichrostachys, A. chundra* and *A. planifrons* (in Tamil Nadu).
7. Tropical dry evergreen forests 0.1 M ha, 0.1%		Carnatic coast which receives little or no summer rainfall	*Memecylon edule, Maba buxifolia*
8. Sub-tropical broad-leaved hill forests, 0.3 M ha, 0.4%		#Nilgiris and Palani Hills, Pachmarhi (Satpura), West of Darjeeling along with Kashmir, Parasnath (Bihar), Khasi, Jaintia, Naga, Manipur Hills of North-Eastern Hills	Forests of *Engelhardita spicata Castanopsis tribuloides, Schima wallichii, Betula cylindrostachys, Phoebe attenuata*, Khasi pine (*P. khasya*); Chir pine has been successfully taped for resin, while Khasi pines have not proved so economical. *Quercus* sp., *Syzygium cumini, Ficus* sp.
9. Sub-tropical forests, 3.7 M ha, 5.0%	Upward of 1,500 11,700 or more in Cherrapunji	750–1,800 m above msl in Himalaya	Chir pine (*Pinus longifolia,* now known as *P. roxburghii*) characteristic of western and central Himalaya
10. Sub-tropical dry evergreen forests, 0.2 M ha, 0.2%		North-west corner of the country	*Olea cuspidata, Acacia modesta, Dodonea*
11. Montane wet temperate forests 1.6 M ha, 2.0%	1,250–2,000	Eastern Himalaya, hill tops of some Nilgiris (1,800–3,000 m, altitude)	*Cedrus deodara, P. wallichiana*, *Quercus lamellosa, Quercus lineata,* maples, *Bucklandia populnea, Alnus nepalensis, Michelia excelsa, Juglans regia, Celtis, Ulmus*
12. Himalayan moist temperate forests 2.7 M ha, 3.4%		Central and western Himalaya areas except where the mean annual rainfall is below 1,000 mm	Lower forms consist of *Quercus leucotrichophora, Quercus dilatata, Pinus wallichiana, Cedrus deodara,* Upper forms consist of *Abies pindrow, Picea smithiana, Quercus semecarpifolia*, East Himalaya Hills have *Q. lineata, Q. lamellosa, Tsuga dumosa, Picea spinulosa, Abies densa, Alnus nepalensis, Pinus wallichiana*

Forest type, area, and % of total	Rainfall (mm)	Area	Major species components
13. Himalayan dry temperate forests, 0.2 M ha, 0.2%		Upper ranges of Himalaya in low rainfall areas	Western Himalaya: *Pinus gerardiana, Cedrus deodara, Quercus ilex*, at higher elevation, *Juniperus macropoda* Eastern Himalaya: *Abies, Picea* Higher hills: *Juniperus wallichiana* Between 2,500-4,000 m: *Larix griffithiana, Populus euphretica, Salix*
14. Alpine forest 3.3 M ha,* 4.3%		Throughout Himalaya (altitude 2,900–3,500 m or even up to 3,800 m)	*Rhododendron, Betula utilis, Juniperus, Abies densa, Arundinaria* occupy the ground
15. Moist alpine scrub		In Himalaya above tree line to about 5,500	The shrubs are rarely more than 1 m in height *Rhododendron, Juniperus* spp. *Betula* spp.
16. Open alpine scrub			Open xerophytic dwarf shrubs, *Juniperus, Carangana, Eurotia, Salix, Myricaria*

*includes all 3 types of alpine forests
#Lower slopes of Himalaya in Bengal and Asom. 800-1,700 m in South (Nilgiris and Palani Hills), about 1,070 in Central region, Pachmarhi (M.P) Parasnath (Bihar) Cherapunji (Asom, Meghalaya)
Source: Pathak and Pateria, 1998

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