State of the Environment Report, 2005

Meghalaya

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Meghalaya

Supported by

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Government of India
New Delhi 110001

Prepared by

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Contents

Foreword

The first state of environment report of Meghalaya was prepared by NEHU in the year 1996 with the initiative from the State Urban Department, Government of Meghalaya. Since then many changes have taken place due to accelerated development processes in the state. Therefore there was an urgent need to re-assess the adverse effects of developmental activities on the environment. Considering the importance of environment, the Planning Commission, Govt. India decided that state of environment should be continuously monitored in different states of the Union. At national level, the Ministry of Environment and Forests was made responsible for this task. This State of the Environment (SoE) report is the outcome of this initiative. It has been prepared through consultative process, in which stakeholders workshops and discussion meetings were held in different parts of the state. Many departments of Government of Meghalaya such as Environment and Forests, Agriculture, Urban Development, Power, Industry, Planning, and Rural Development participated in these meetings. Besides, members from research organizations, civil society, NGOs and development agencies also participated in the consultation process. To my knowledge such a wide-ranging consultations were not made earlier in the state for any issue similar to SoE. The data and information available on different aspects of environment were collected from different sources including the SoE workshops. A team of well - known environmental scientists and ecologists, has prepared the report. On behalf of the Government of Meghalaya, I congratulate the authors at North-Eastern Hill University and Development Alternatives for bringing out such a unique document highlighting the environmental concerns of the state. I am confident, the report will be of immense help in preparing an action plan for the management of state's environment, and will also be useful in developing the strategies for managing the natural resources of the state. The report has identified key environmental problems that the state is facing today and has suggested several remedial measures to deal with these problems effectively. I hope the development planners would adequately address the environmental concerns associated with their respective activities, while implementing the development agenda. The SoE process should be a continuous process in Meghalaya to update the data on several aspects of the environment for which either the recent data is not available or primary data need to be generated. Let the State of Environment Report of Meghalaya: 2005 be the beginning of this process and we must endeavour to continue this process in future. Efforts should also be made by all the departments to implement the suggestions made in the report for the effective protection and management of the environment of Meghalaya.

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Acknowledgements

The authors are thankful to the Ministry of Environment and Forests, Government of India, New Delhi for initiating the State of Environment (SoE) Reporting process in Meghalaya and sanctioning the "SoE Reporting in Meghalaya" project. Development Alternatives, New Delhi and the Department of Environment and Forests, Government of Meghalaya facilitated the process being the National Host Institution and the State Nodal Agency, respectively. Many individuals from civil society, institutions, government and non-government organizations, and state government departments have contributed to the SoE process immensely. Since the reporting process was a combination of consultation with all the stakeholders following a participatory approach as well as incorporation of scientific data available, the report is a unique document, which is owned by all the stakeholders. This has been possible because of overwhelming response and participation of people from all walks of life in the stakeholders worksops, organized at Shillong, Tura and Jowai. It would not have been possible to capture the people's perception on environmental issues without their active participation. In fact, issues have been prioritized based on the findings of these workshops. The authors are grateful to each one of them. The responsibility of organizing/ arranging local logistics for these workshops were shouldered by the Divisional Forest Officer, Jowai, and Shri P.R. Marak, DFO, Tura. We sincerely thank them and their team of officials for making excellent arrangements for the workshops. The data collection and compilation are the two most important component of any reporting process. The untiring effort made by Dr. O.P. Tripathi and Dr. K. Upadhyaya in this work is commendable. We thank all those departments, particularly the Meghalaya Pollution Control Board for providing the data on water pollution. The constant support and inspiration from Shri V.K. Nautiyal, Principal Chief Conservator of Forests, Meghalaya during the entire SoE process is praiseworthy. The authors are indebted to Shri Yushuf Shullai, Conservator of Forests, who extended all his supports as the nodal officer in the state nodal agency, i.e. the State Forest and Environment Department. The support received from Dr. K. Vijaya Lakshmi of Development Alternatives during the whole SoE process is highly appreciated. We recognize the contributions made by Shri Sanjay Vashist and Dr. Sanjay Tomar of Development Alternatives during the initial stage of the process. We are thankful to all the authors of the source materials from which the State of the Environment report of Meghalaya: 2005 has freely drawn information and ideas.

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The State of Environment Report of Meghalaya has been prepared, by the Department of Botany, North-Eastern Hill University, Shillong, the State Host Institution. The Environment Systems Branch of Development Alternatives, New Delhi facilitated the process of SoE Reporting as National Host Institution under the project, "Facilitating State of the Environment Reporting". The Department of Environment and Forests, Government of Meghalaya, was the state nodal department for SoE process. The authors of the Report and other experts involved in SoE process from these organizations are listed below:

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The forest areas in Meghalaya has reduced from 69.06% to 63.06% over 15 years. The major environmental problems result from population pressure, conversion of forestland into agricultural fields, deforestation, urbanization, mining and industrialization. The increasing anthropogenic stresses may further aggravate the situation in the future. Reasons include shifting cultivation, mining, urbanization and industrialization.

Part I

Executive Summary

During the past few decades, there has been considerable deterioration in the quality of the environment in Meghalaya. Life support systems namely air, land, water and vegetation are under considerable strain. The major environmental problems result from population pressure, conversion of forest land into agricultural fields, deforestation, urbanization, mining and industrialization. The increasing anthropogenic stresses of various kinds are likely to further aggravate the environment in the future.

Under the SoE process, three different workshops were organized in Shillong, Tura and Jowai, to get the perception of stakeholders on environmental issues, identification of the issues and prioritizing them. There was an enthusiastic response from the participants representing Forest Department, PHE, Industries Department, Pollution Control Board, Agriculture Department, Urban Affairs Department, other concerned departments, academics, non-governmental organizations and civil society. They were first exposed to the DPSIR framework of the SoE process and guidelines suggested by the Development Alternatives (National Host Institution) for SoE reporting. The participants, representing a wide cross section of society, identified environmental issues, prioritized them and suggested responses as well (Fig. 1 and Table 1). The environmental problems of the state have been categorized into green (pertaining to vegetation and related areas), blue (problems relating to water) and brown (problems relating to urbanization and industrialization).

SoE process in Garo Hills of Meghalaya, where most stakeholders participated in identifying, prioritizing and discussing various environmental issues under DPSIR framework

These perceptions were cross-checked with the available relevant scientific literature by the North Eastern Hill University (NEHU) faculty entrusted with the responsibility of preparing the State of Environment Report for Meghalaya, 2005. Besides taking into consideration the people's perception of environmental issues of Meghalaya, the scientific robustness of the report has also been ensured by the State Host Institution (SHI).

The state of Meghalaya is rich in natural forest resources. Besides timber, a number of non-timber forest produce including cane, bamboo, broom-grass and other commercially important grass species, mushroom, orchids, oil yielding trees, honey and wax are extracted from the forests every year in large quantities. The forest areas in the state of Meghalaya, based on legal status, is 9,496 sq. km. According to Satellite data, the forest cover of Meghalaya in 1980 was 69.06% and it reduced to 63.09% by 1995. The trend of forest cover shows that during 1980-89, maximum deforestation has taken place. Shifting cultivation which is widely practiced in the state, mining for coal and limestone, urbanization and industrialization are the major factors contributing to the depletion of forest cover in the state.

Due to the rising human population in the state, the pressure on forest land for cultivation has increased, and consequently, the jhum cycle is now reduced to 2-3 years from 10-15 years, earlier. The area affected by shifting cultivation in the state during the last 10 years (1987-1997) was about 0.18 million ha. The jhumia population dependent on jhum is 217,640 and the annual area under jhum in the state is 364.13 sq. km.

Coal mining has damaged the environment to a large extent in the state through forest clearing, and increase in acidity of soil and water. The rural areas are badly affected by unscientific mining activities being carried out in different parts of the state.

The state of Meghalaya is rich in plant diversity with 3,128 species of flowering plants including 1,237 endemic species and several valuable medicinal plant species. Some highly exploited and endangered species include *Panax pseudoginseng* and *Rouvlfia serpetania*. Most of the endemic and threatened species are confined to protected forests and sacred groves. Species endemic to Meghalaya include *Aeschynanthes parasiticus, A. superba, Callicarpa psilocalyx, Citrus latipes, Ilex embeloides, Impatiens khasiana, Nepenthes khasiana, Paramignya micrantha* and many others. Species that were common about 20 to 30 years ago have become rare (e.g., *Dipteris wallichii, Cyathea gigantea, Ilex embeloides, Styrax hookerii* and *Fissistigma verrucosum*) due to overexploitation, deforestation and habitat destruction.

Beside a large number of amphibian, reptile, fish and bird species, more than 110 mammal species including elephants, wild buffalo, sambar and barking deer, red jungle fowl, hornbills, civets, etc. These include elephants, wild buffalo, amphibians, reptiles, Sambar, barking deer, civets etc. are found in the forests of Meghalaya.

If shifting cultivation and mining in their present form and magnitude are allowed to continue, land degradation, water pollution and the impoverished living condition of the poor in rural Meghalaya will further deteriorate. To address the adverse impacts of deforestation, shifting cultivation, mining, water pollution, over-exploitation of plant and animal species – suitable policy, strategies and action plans need to be evolve. Only then, will conserving natural resources of the state and protecting the environment for the welfare of the present and generations, be made possible.

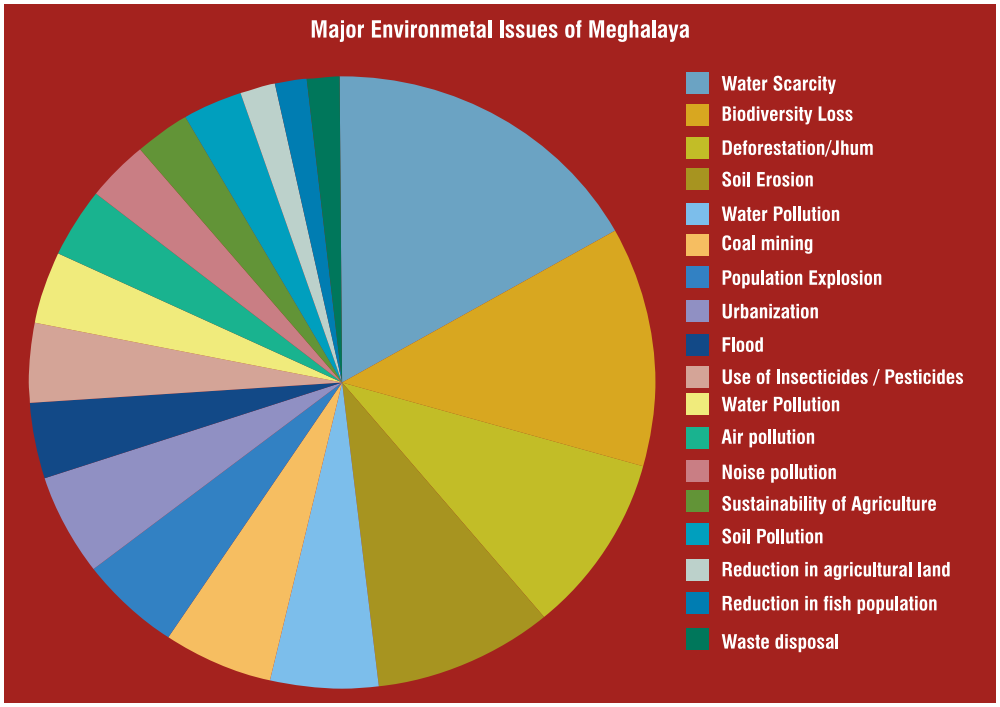


Fig. 1: Environmental isues of Meghalaya

Table 1: Environmental Score Card for Meghalaya

Issues	Trends	Causes	Indicators	Value	Period covered
Green					
Biodiversity loss	Increasing	❖ Habitat destruction ❖ Deforestation ❖ Shifting cultivation ❖ Over-extraction ❖ Fragmentation ❖ Land use changes	Species richness Population size of endemics threatened category of species	30	1990-2004
Deforestation	Increasing	❖ Shifting cultivation ❖ Over-extraction ❖ Land use changes ❖ Change in ownership pattern of land ❖ Loosening of the control of traditional institutions	Forest cover Yield Species composition Forest floor and soil characteristics	23	1987-2001
Shifting cultivation	Decreasing	❖ Low output-input ratio ❖ Availability of other alternate incomes due to increased commercial activities ❖ Migration of rural population to urban centres	Area under shifting cultivation	23	1983-1997
Brown					
Coalmining	Increasing	❖ No regulation due to private ownership of land ❖ Easy accessibility to international market	More area under mining More pollution in the water bodies	13	
Urbanization	Increasing	❖ Increase in population ❖ Search for better job opportunities and better quality of life	Increase in urban population	13	
Blue					
Water scarcity	Increasing	❖ Increase in population ❖ Destruction of catchment areas of water bodies ❖ Poor water supply infrastructure, managemnt and system	Difficulty in getting water for domestic use	41	
Water pollution	Increasing	❖ Coal mining ❖ Domestic waste disposal	Polluted water bodies	23	

Part II

Overview

Meghalaya was carved out of Assam to become an autonomous district on April 2, 1970. It was declared a full fledged state of the Indian Union on January 21, 1972. The state of Meghalaya comprises Khasi, Garo and Jaintia hills. The state has a 496 km long international boundary with Bangladesh in the south and west. It is bordered by Assam in the north and east. The eastern part is bound by the Karbi Hills which is a continuation of the Meghalaya plateau. On all other sides of the state lies an extensive plain drained by the river Brahmaputra (in the north and west) and the river Surma and its tributaries (in the south).

A summary of the demographic information pertaining to the state is given in Annexure I.

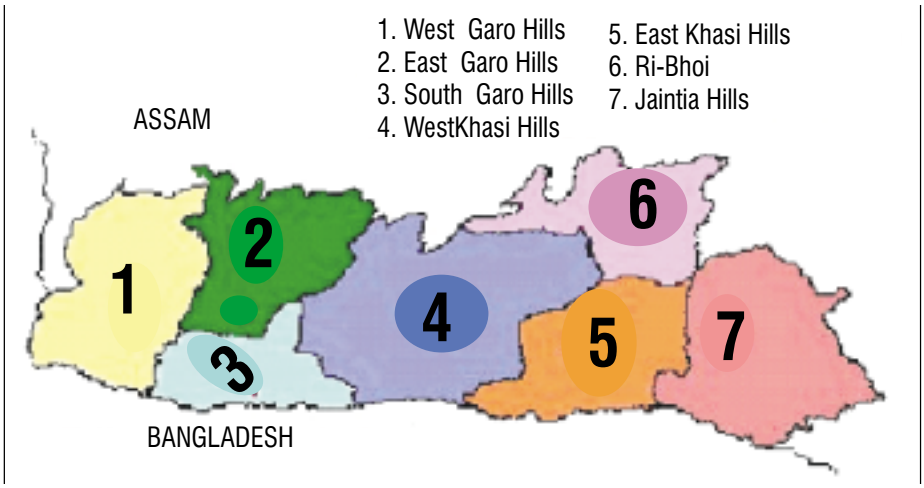


Fig 2: Map of Meghalaya showing different districts

Biophysical profile

The state of Meghalaya with a geographical area of 22,429 sq. km, is situated in northeast India. It lies between latitudes $25^0$02' and $26^0$07'N and longitudes $89^0$49' and $92^0$50' E. The elevation ranges from 60 m to 1,950 m asl. The climate is monsoonic with distinct warm-wet and cold-dry periods. The period between May and October is wet. The dry period extends from November to February. The western and southern parts of the state are warmer than the central upland where mean minimum temperature stands at 20^0C. Average maximum and minimum temperatures and annual rainfall in the state varies from 5^0C to 32^0C, and 4,000 mm to 11,436 mm, respectively. Cherrapunjee and Mawsynram, located in the southern part, receive the highest rainfall spots of the world.

The soils of Meghalaya are largely lateritic. In the central plateau soil is predominantly red and in the northern border areas there are typical upland loam, and old and new alluvial soils. The southern parts have sandy gravel and clay soil. In general, soils are highly leached, acidic and deficient in phosphorus and potash contents.

Socio-economic and cultural patterns

According to 2001 census, the population of the state is 2,306, 069 with a density of 103 persons per square km. The scheduled tribe populations (mainly belonging to Khasi, Jaintia and Garo tribes) constitute 85.53% of the total population. The Garos inhabit western Meghalaya, the Khasis, central Meghalaya and the Jaintias, eastern Meghalaya. In the interior of the state (excluding urban populations), the tribal population percentage increases to 97.3% in Garo hills, 77.4% in the Khasi hills and 95.1% in the Jaintia hills. The decennial growth rate (1991-2001) of the tribal elements in the population has been 29.40%. Region wise, it was 24.50% in the Garo hills; 29.50% in the Khasi hills and 36.50% in the Jaintia hills. The literacy rate is 63.31% (Annexure II).

Political and Governance Structure

Districts and Headquarters

The state of Meghalaya has been divided into 7 districts (Fig. 2). These are: East Khasi Hills, West Khasi Hills, East Garo Hills, West Garo Hills, South Garo Hills, Ri Bhoi, and Jaintia Hills. There are 8 subdivisions (other than the district headquarters) and the districts are divided into a total of 39 CD blocks. The total number of villages in Meghalaya is 5780. The geographical area and headquarters of districts and CD blocks are shown in Annexure III. Other functional units of the State Government administration are given in Annexure IV.

Autonomous District Councils

There are three Autonomous District Councils (ADCs) in Meghalaya. They are Khasi Hills Autonomous District Council, Jantia Hills Autonomous District Council and Garo Hills Autonomous District Council. All three have been established under the VI Schedule of the Indian Constitution. The ADCs are constituted by the members (Member of District Council) representing the District Council constituencies who are elected to office through a regular election like members of the Legislative Assembly. The leader of the party which gets maximum representation in the District Council is appointed by the Governor of Meghalaya as the Chief Executive Member (C.E.M.) of the District Council. On the advice of the C.E.M., some members are appointed by the Governor as Executive Members who along with the C.E.M. constitute the Executive Committee of the District Council and exercise their executive powers. The ADCs have executive as well as judiciary power in relation to land disputes and social conflicts.

Economic base

Agriculture is the main occupation of the people of Meghalaya. The Garos practice shifting (jhum) cultivation. They are also good fishermen but indifferent hunters. The Hajongs however, do not practice 'shifting' cultivation. The Khasi have four main types of land uses.

(1) the forest land for jhum cultivation
(2) wet paddy land
(3) high grass land and
(4) homestead land which is situated close to their courtyard

Some of them are engaged in beekeeping, as labourers who are employed in road and building construction, as porters for carrying potatoes, etc. In addition to the above occupations, educated individuals have taken up teaching, government jobs and private services as their profession. Besides, a very small fraction of the population depends on business of varying natures and sizes.

Meghalaya has abundant but untapped natural resources, including coal, limestone, kaolin, feldspar, quartz, mica, gypsum, bauxite, and other minerals. Its sillimanite deposits (a source of high-grade ceramic clay) are reputedly the best in the world and account for almost all of India's sillimanite output. Meghalaya has no heavy industries. Small-scale industries include cement, plywood, and beverage factories, along with recently established ferro-alloys factories in Burnihat area.

Important fruits grown in Meghalaya are orange, pineapple, lemon, guava, jackfruit and bananas, while potato, jute, mesta, cotton, areca-nut, ginger, turmeric, betel leaf black pepper and broom grass are the chief commercial crops. Of late, 'Jhum' or the shifting system of cultivation is being replaced by more scientific cultivation methods, bringing land under permanent cultivation.

Part III

Key Environmental Concerns

Three Stakeholders' workshops were organized to ascertain and prioritize various environmental issues from the stakeholder's perspective. The venues of these workshops were, Shillong (for Khasi Hills), Jowai (for Jaintia Hills) and Tura (for Garo Hills). Exercises were conducted involving the stakeholders to list out environmental issues and to prioritize them for each of the three geographical regions. The results of these exercises are presented in the figures 3-6.

For the entire state, water scarcity was perceived as the most important problem followed by biodiversity loss, jhum/deforestation, urbanization, water pollution, population explosion and coal mining.

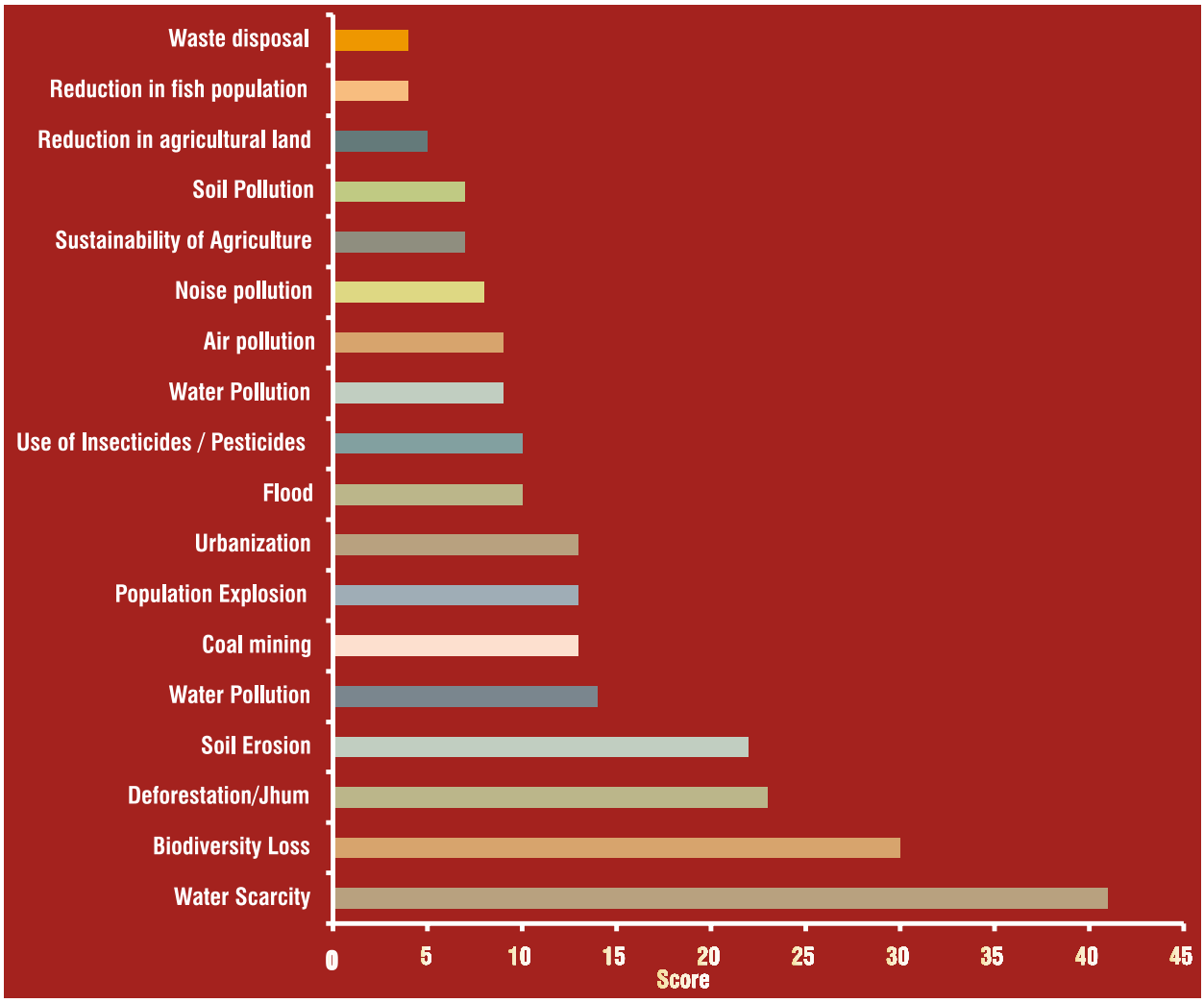


Fig. 3: Major environmental issues of Meghalaya: Stakeholders' perception

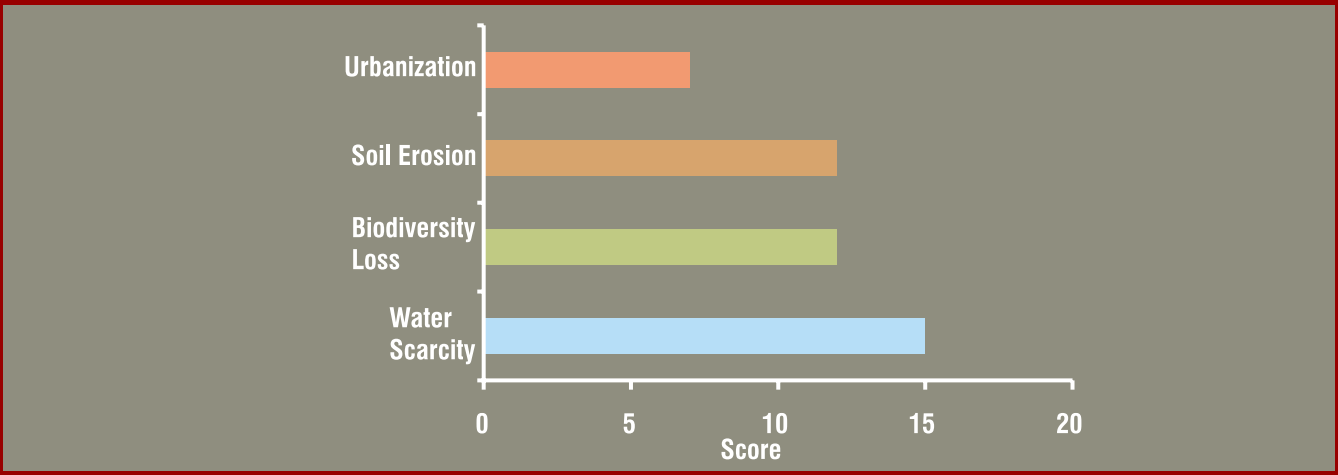


Fig. 4: Major environmental issues of Khasi Hills

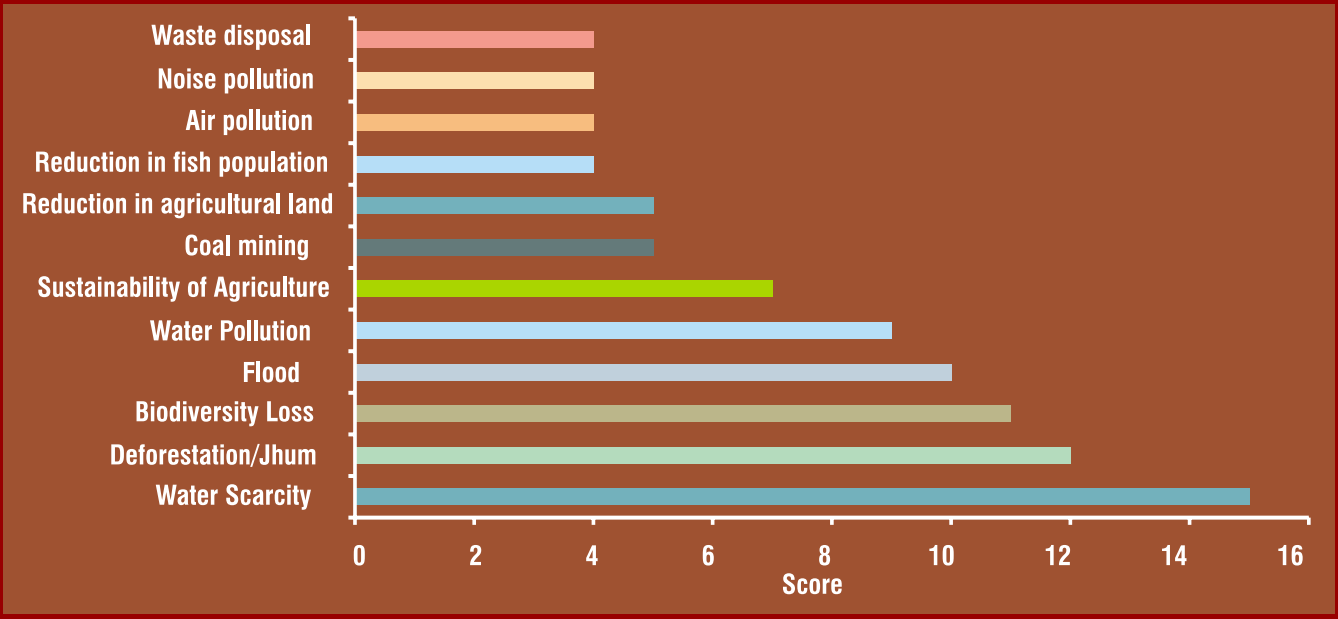


Fig. 5: Major environmental issues of Garo Hills.

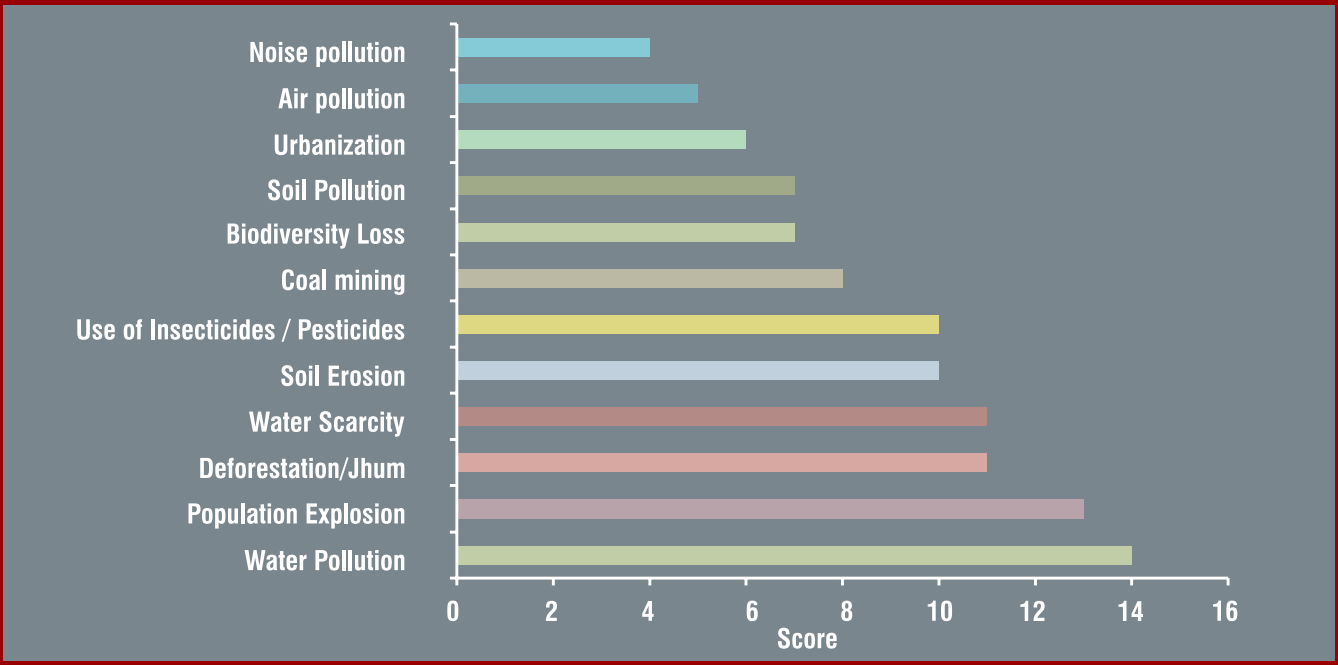


Fig. 6: Major environmental issues of Jaintia Hills.

Water pollution, population explosion and deforestation/jhum were the three top problems in Jaintia Hills, while water scarcity, biodiversity loss and water pollution were most important problems in Garo Hills. In Khasi Hills, the four most important environmental problems are, water scarcity biodiversity loss, soil erosion and urbanization.

The stake holders' perception and the available scientific studies were finally considered together to draw a priority list of environmental problems which are as follows:

1) Biodiversity loss
2) Deforestation
3) Shifting cultivation
4) Water pollution
5) Coal mining
6) Urbanization

The issues were classified under green, blue and brown categories. As mentioned above, three issues under green category (Biodiversity loss, Deforestation and Shifting cultivation), two issues under brown category (coal mining and urbanization) and one issue under blue category (water pollution) were analyzed.

Deforestation

Water scarcity

Coal mining

Deforestation

Vegetation

The forests of Meghalaya can be broadly grouped into tropical, subtropical and temperate types. The Indian Institute of Remote Sensing have classified the vegetation of Meghalaya into tropical evergreen, tropical semi-evergreen, tropical moist deciduous, subtropical broad leaved, subtropical pine and temperate forest types, grasslands and savannas (Fig. 7).

An overview of deforestatiom

Tropical forests

These forests occur up to an elevation of 1,200 m where average annual rainfall ranges between 100 and 250 cm. They may be evergreen, semi-evergreen, and moist deciduous depending on the annual rainfall. Tropical evergreen forests occur in high rainfall as well as near catchments areas. They are rich in species diversity. The tropical semi-evergreen forests occupy the northeastern and northern slopes of the state, typically up to elevation of 1,200 m, where annual rainfall is relatively less. The number of species here are more than the evergreen zone (Tripathi 2002). The tropical moist deciduous forests occur at lower elevations where annual rainfall is below 150 cm. Typical natural deciduous forests do not occur in Meghalaya. These are sub-climax or man-made forests, characterized by seasonal leaf shedding and profuse flowering of the trees. Occurrences of fire are common in these forests. The trees of the deciduous canopy are lofty with straight bole and spreading crown.

Subtropical or Temperate Forests

The temperate forests occur at 1,500 m and above, mostly along the southern slope of Khasi and Jaintia Hills. The annual rainfall in these areas ranges from 200-500 cm with a severe winter during November to March. Ground frost is common during December and January. Subtropical Pine forests have developed as a stable secondary community on the disturbed evergreen and semi-evergreen subtropical broad-leaved forest sites, which are seasonally dry and nutrient-poor.

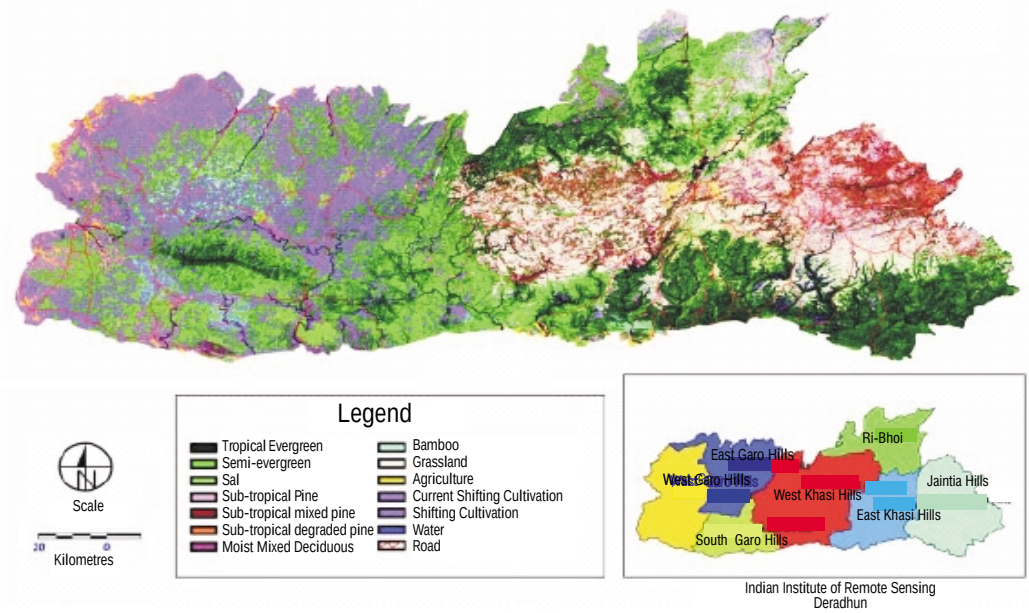
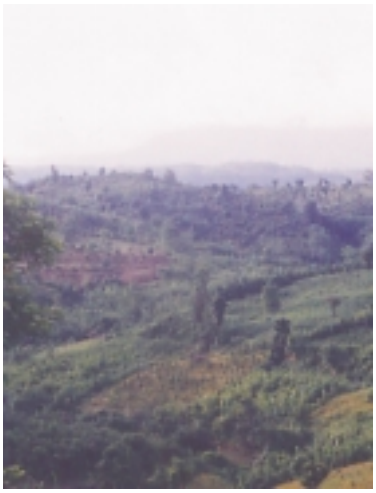


Fig. 7. Vegetation type/land use map of Meghalaya

Grassland and Savanna

Typical grassland is not found in the state. The rolling grasslands covering large areas in Khasi and Jaintia Hills and in major parts of West Garo Hills are found on degraded land developed either due to biotic pressure or due to interactive influence of topography, climate, fire and grazing.

The forest cover based on satellite data of December, 1998 is 15,633 sq. km which is 69.70% of the total geographic area of the state. Dense forest extends to 5,925 sq. km and open forest to 9,708 sq. km. A comparison with the previous assessment reveals that there is net loss of 24 sq. km. Based on the 1999 FSI report there has been an overall increase of 1,881 sq. km of dense forest. This is the result of improvement of 1,877 sq. km of open forest and 32 sq. km of non-forest. On the other hand there has been a degradation of 28 sq. km of dense forest to open forest. The decrease of 1,905 sq. km of open forest is on account of conversion of 1,877 sq. km of open forest to dense forest.



An overview of Forests of Meghalaya

Forest cover

According to the State of Forest Report (FSI 2001), the actual forest cover of the state is 15,584 sq. km. This accounts for around 69.5% of the state's geographic area. Per capita forest area in the state is 0.64 hectares compared to the national average of 0.11 hectares (Table 2). However, the total recorded forest area is 9,496 sq. km. The area of reserved and protected forests under the control of the state government is only 1,124 sq. km. The Unclassed Forests, managed by Autonomous District Councils, village durbars and other traditional institutions, and private owners cover an area of 8,372 sq. km. During 1985-87, 73.41% (16,466 sq. km) of the total geographical area of the state was under forest cover. It decreased to 69.75% (15,645 sq. km) by the year 1987-89 and then increased to 69.48% (15584 sq. km) in 1999-2001 (Table 3). The forest cover in different districts is given in Fig. 8.

Table 2: Forest-man ratio in Meghalaya.

Population	Geographical area '000 ha	Total forest ($x10^3$ ha)		Dense forest ($x10^3$ ha)	Open forest ($x10^3$ ha)	Per capita forest Cover in ha
		Recorded	Cover			
23,06, 069	2243	949.60 (42.34)	1563 (69.70)	592	971	0.64

Figures in parentheses represent the forest area as percentage of the total geographical area. Dense Forest (>40%Canopy cover), Open Forest (10-40% Canopy cover)

Table 3: Change in forest cover (sq. km) in the state since 1991 (FSI report, 1999)

State	1991	1993	1995	1997	1999
Meghalaya	15,875	15,769	15,714	15,657	15,633

Source: www.meghalaya.nic.in

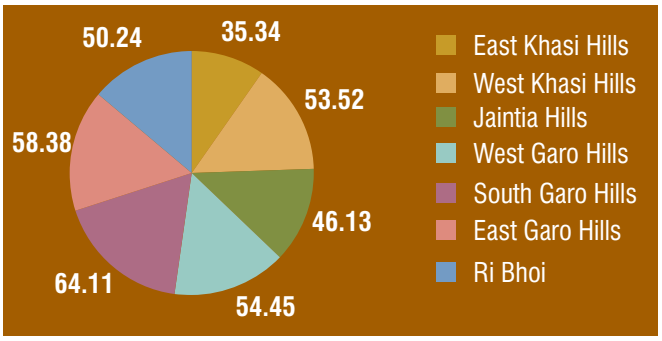


Fig 8: Forest cover (%) in different districts of Meghalaya

Temporal changes in forest cover

The forest cover of Meghalaya decreased from 1981 to 1999; it was highest during 1980-89 (Fig. 9, Table 3). The areas under different kinds of forests in Meghalaya are given in Fig. 10. Factors contributing to deforestation have been analysed in Fig. 11.

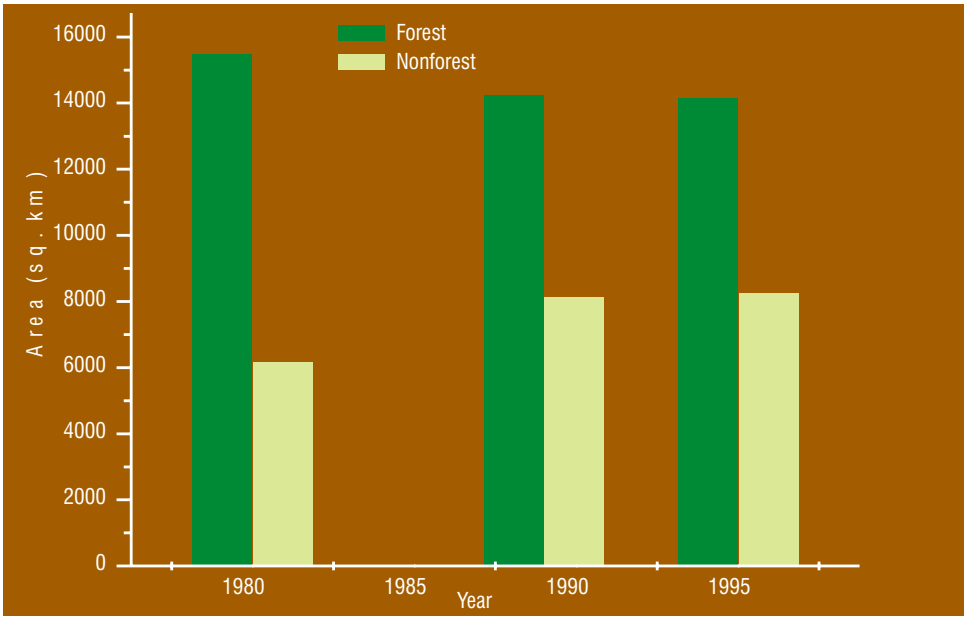


Fig. 9: Forest cover of Meghalaya based on FSI report

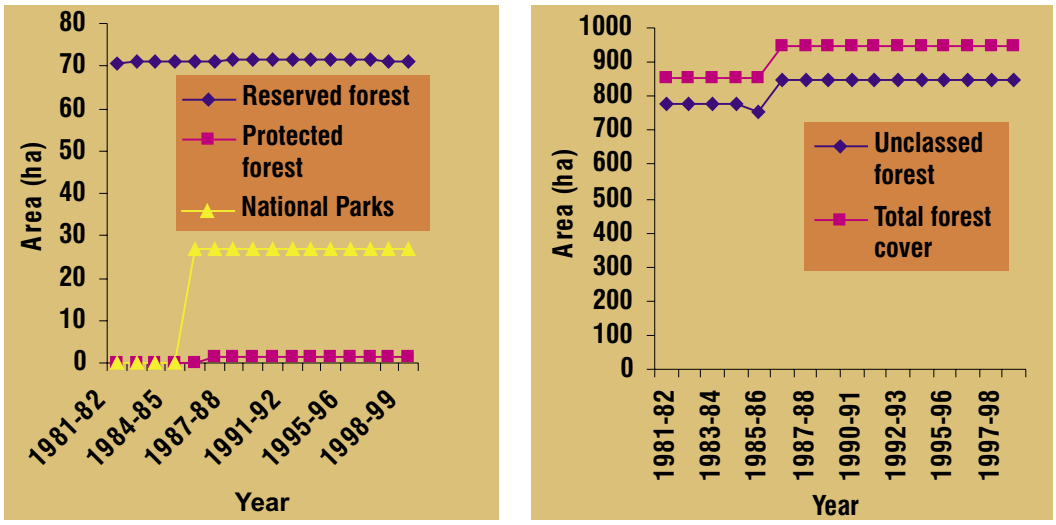


Fig. 10: Area under different kinds of forests during 1981 and 1999

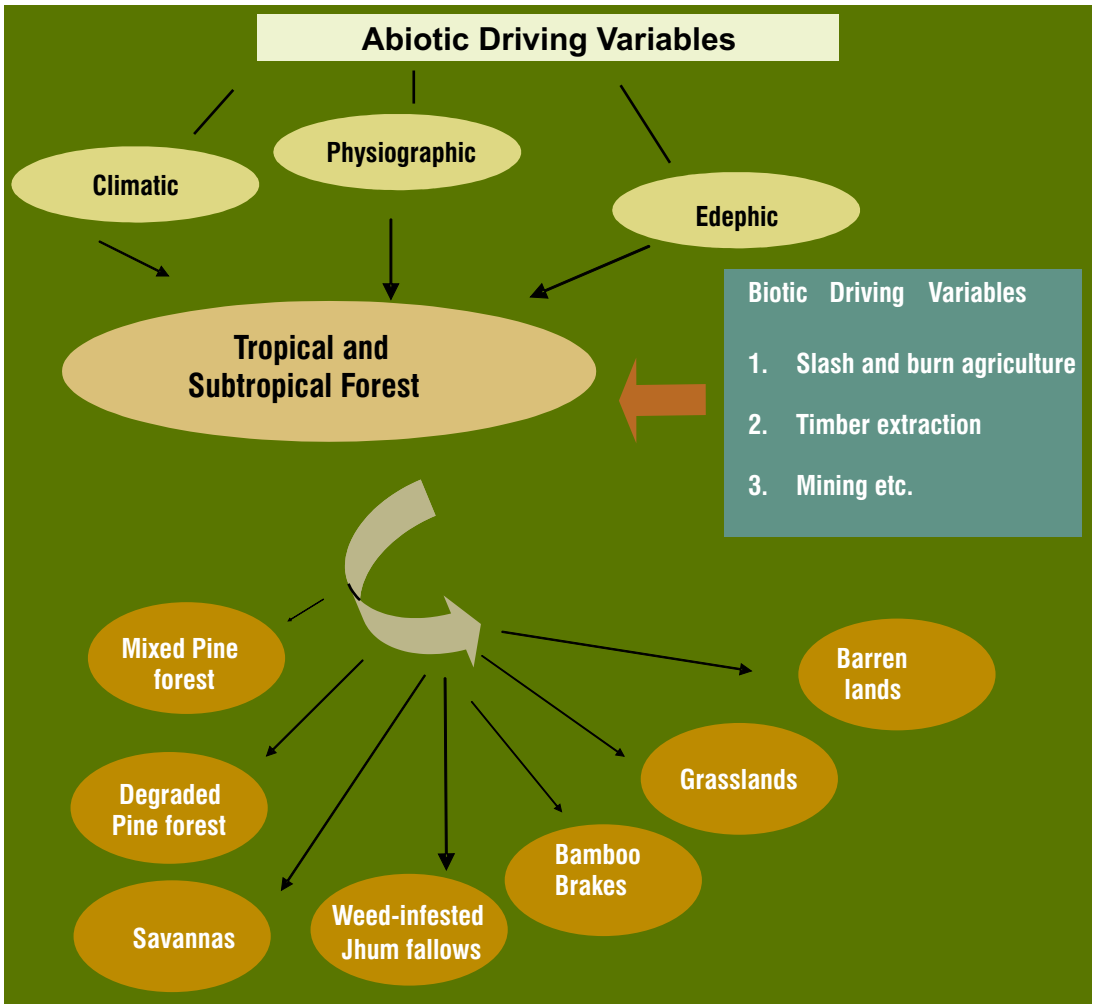


Fig. 11: Factors responsible for forest destruction and fragmentation in Meghalaya.

Forest resources

Besides timber, a number of non-timber forest produce including cane, bamboos, broom-grass, mushrooms, orchids, commercially important grass species, and oil yielding trees, honey and wax are extracted from the forests every year in large quantities. Important medicinal plants such as *Taxus baccata, Tinospora cordifolia, Vinca rosea, Strychnos nux-vomica, Dichora febrifuga, Hodgsonia hiteroclita, Scutellaria discolour, Smilax sp., Solanum khasianum, Dioscorea deltoides, Dioscorea prazerai, Dioscorea bulbifera, Holarrhena antidysenterica* etc. are found in the forests. Gums, resins, edible wild fruits and tubers and cinnamomum, large cardamom are other important non-timber forest resources of the state.

Forest ownership

Unlike the rest of the country where forests are mostly owned by the state and managed by the state forest department, in Meghalaya substantial forest areas are under the unclassed category, and are

Extremely adverse habitat conditions of West Khasi Hills. Once deforested difficult to regenerate.

owned by private individuals, clans, village councils, district councils and other traditional community institutions. The autonomous district councils control the unclassed forests of 8,503 sq. km (96%).

Forest administration

Besides the State Forest Department and Autonomous District Councils, private individuals, communities and clans own the forests in Meghalaya. The ownership rights over land and resources are further protected by the sixth schedule of Indian Constitution. The acts and rules framed by the state and national governments are therefore not applicable to such forests. The district council acts are too weakly enforced, as there are not adequate forest personnel in the district council to enforce them. Hence, most community forests are virtually under no management and do not come under the effective enforcement of any of the forest laws.

Unregulated shifting cultivation by the local tribal populations has been a major threat to forest particularly in unclassed and community forests. In spite of the efforts of many state and national agencies, a viable land-use option to shifting cultivation is yet to be found. There is a need to work out a regulatory mechanism to control over-exploitation of forests, where the landowners themselves will be legally bound to sustainable harvest and manage their own forests.

Forest fragmentation

Shifting agriculture, logging, mining and other human activities have been responsible for fragmentation, destruction and degradation of the forests in the state. High rainfall and hilly terrain have further accentuated the impact of human activities on the forest. As a result, the forests are getting fragmented into small patches. The pine forests are most disturbed and highly fragmented. The degraded forestlands support a variety of successional communities ranging from weed-dominated communities on recently abandoned Jhum fields to pine forest and grassland on frequently burnt and nutrient-deficient sites (Figs.12 and 13).

An overview of forest fragmentation

Seismic activities, frequent landslides and resultant soil erosion destroy the primary vegetation in some places. While these natural causes have contributed only marginally to the change in vegetation type, it is the activity of man that has led to the irreversible transformation in the landscapes and has resulted in loss of biodiversity in the entire

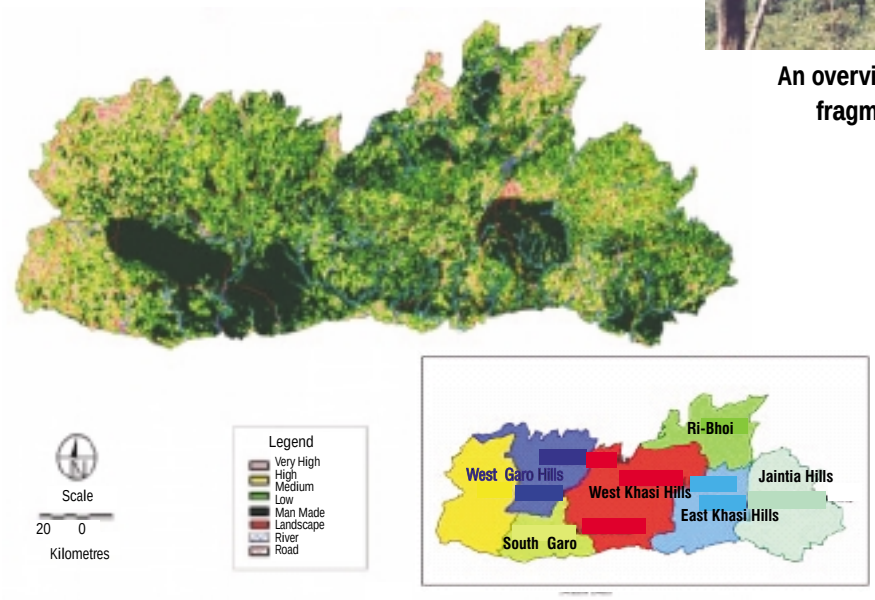


Fig. 12: Fragmentation map of Meghalaya

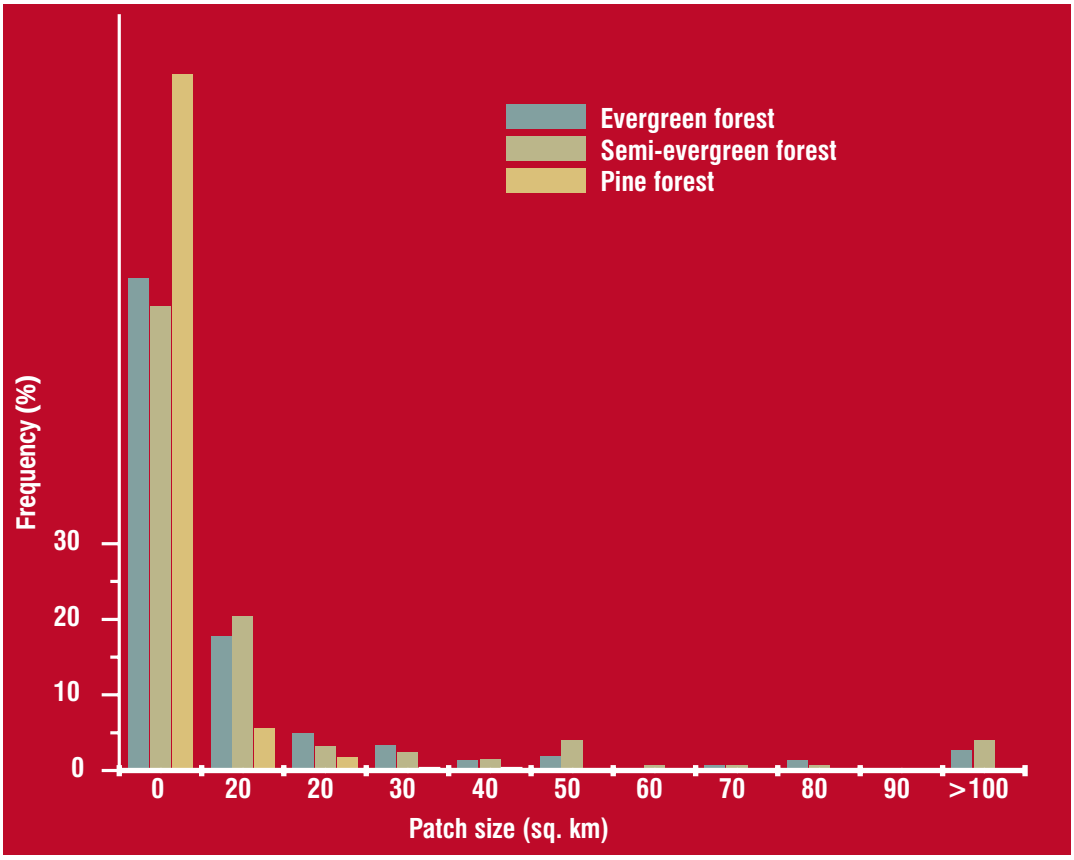


Fig. 13: Fragmentation pattern of major forest types of Meghalaya.

(Source: Tripathi et al. 2003)

region. Human influences have pushed many species to the brink of extinction and have caused havoc to natural fragile ecosystems. Such devastations to natural ecosystems are witnessed almost everywhere in the region and is a cause of great concern.

It is often quoted that the state with about 69% of the total geographical area of is under forest cover is a forest surplus region, but the quality of the forest has deteriorated; the dense forests with canopy closure of 40% or more becoming degraded into open forest or scrub.

Since the state is predominantly mountainous, deforestation and the resultant loss of soil, especially in the hill areas, are leading to increased siltation of rivers and streams. The deep pools that are the favoured habitats of many species are rapidly becoming shallow and choked with silt, leading to a decline in habitat. At the same time, swamps, marshes, and other wetlands are increasingly being reclaimed for urban and agricultural expansion.

The DPSIR analysis for deforestation has been done in Table 4 and Fig. 15.

Impact of forest destruction

- Change in land-cover and land-use pattern
- Qualitative change in species composition and structural organization of natural communities
- Decrease in primary productivity of natural and agro-ecosystems
- Fertility loss in soil due to sediments and nutrient losses

Green Issues

- Loss in agricultural and horticultural biodiversity
- Water scarcity

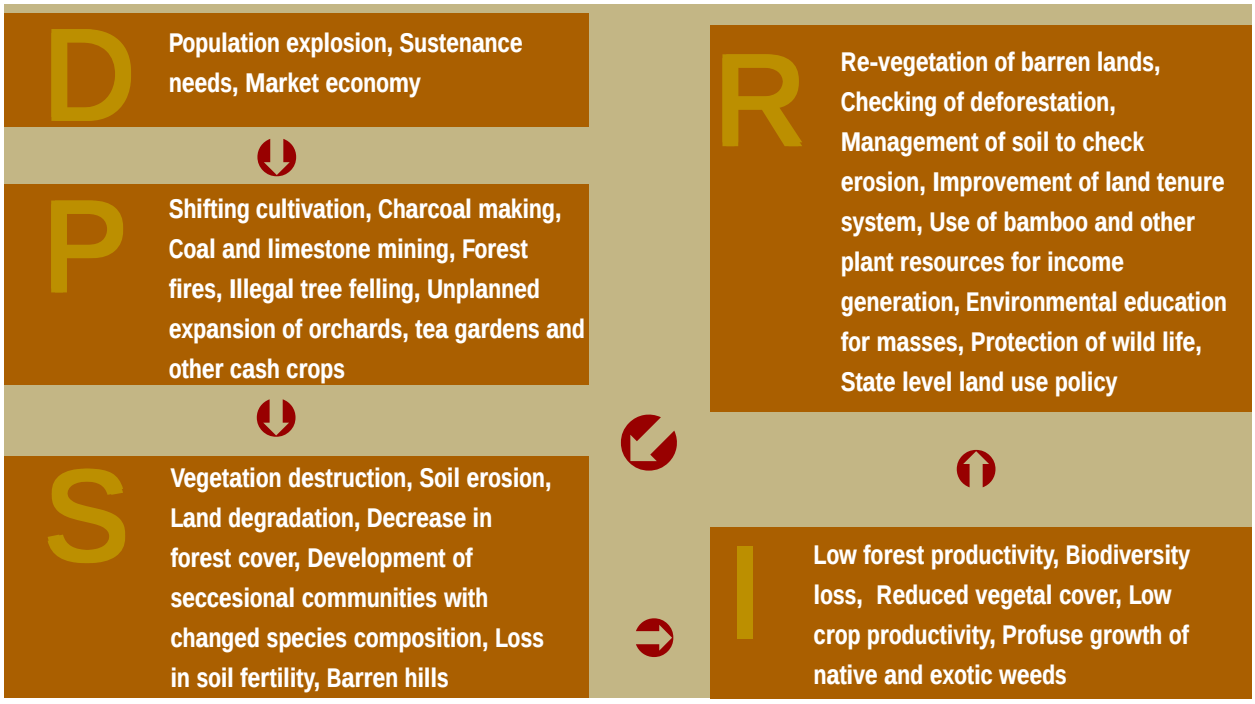


Fig. 14: DPSIR analysis for deforestation

Table 4: DPSIR analysis for deforestation

Driving force	Pressure	State	Impact	Response
Population explosion, Sustenance needs, Market economy	Shifting cultivation, Charcoal making, Coal and limestone mining, Forest fires, Illegal tree felling, Unplanned expansion of orchards, tea gardens and other cash crops	Vegetation destruction, Soil erosion, Land degradation, Decrease in forest cover, Development of seccesional communities with changed species composition, Loss in soil fertility, Barren hills	Low forest productivity, Biodiversity loss, Reduced vegetal cover, Low crop productivity, Profuse growth of native and exotic weeds	Re-vegetation of barren lands, Checking of deforestation, Management of soil to check erosion, Improvement of land tenure system, Use of bamboo and other plant resources for income generation, Environmental education for masses, Protection of wild life, State level land use policy

Green Issues

Shifting Cultivation

Meghalaya is basically an agricultural state with about 80% of its total population depending entirely on agriculture for their livelihood. During the last twenty-five years the total cropped area in the state has increased by about 42 per cent. The major food crops are rice and maize. The state is known for its horticultural crops like orange, lemon pine-apple, guava, litchi, banana, jack fruit and some temperate fruits such as plum, pear, and peach. Potato, ginger, turmeric, black pepper, areca-nut, bay leaf, betel vine, short-staple cotton, jute, mesta, mustard and rape-seed, etc. are some of the important cash crops. At present people are also growing non-traditional crops like tea, cashew nut, oilseeds, tomato, mushroom, wheat and pulses.

Forest clearing for Jhum cultivation

Almost the entire state is influenced by age-old practice of slash and burn agriculture, except some pockets of valley bottomlands. This practice destroys the protective and productive vegetation in preference to a very brief period of immediate crop production. Commonly known as "Jhum", it was valid for those days when human population was sparse and pressure on land was negligible. During that time the Jhum cycle, the intervening fallow period between two cropping periods, was long ranging from 50 to 60 years. Now it has been reduced to 3-5 years in the western Meghalaya and 1-3 years in the central and Eastern parts of the state. This is alarmingly short for the recovery of the soil fertility level, leading to progressive fertility loss and extensive land degradation and imbalance in the socio–economic setup of the village communities.

Because of the hilly terrain, settled cultivation is practiced only in a small portion of the total cultivated land, mostly confined to the valleys. In view of the high labour cost and energy input involved in terrace cultivation, and in absence of other viable alternatives to shifting cultivation, the majority of the population of the state continues to depend on shifting cultivation for their subsistence livelihood (Fig. 15). As per the data given by the Task Force on Shifting Cultivation, Ministry of Agriculture, 1983, 52, 290 families in the state were practicing shifting cultivation on 530 sq. km land area annually (Table 6). According to FSI 1997, the cumulative shifting cultivation area during the period 1987 to 1997 was 0.18 million ha. Thus, as on 1997, the average annual area under shifting cultivation works out to 180 sq. km, thereby indicating a declining trend in shifting cultivation area.

Table 5: Shifting cultivation in Meghalaya

Annual area under shifting cultivation (sq. km)	Fallow period (in years)	Minimum area under shifting cultivation one time or other (sq. km)	No. of families involved in shifting cultivation
530	5-7	2,650	52,290

Source: Report of the Task Force on Shifting Cultivation, Ministry of Agriculture, 1983

Table 6. Land use classification (area in sq. km) of Meghalaya (1994-95)

Forest Area	Area under non-agricultural use	Barren and uncultivable land	Cultivable wasteland	Others	Current fallows	Abandoned fallow land	Net area sown
938	84	142	484	160	66	166	201

Source: Modified from North-Eastern Council Statistics, 2000

Green Issues

Clandestinely, shifting cultivation is being practiced on the revenue, reserve forests and protected forests. Although shifting cultivation is a non-viable resource-utilization practice, tribals are still clinging to this primitive practice to sustain themselves and their families mainly due to non-availability of other employment avenues. As per the Ministry of Agriculture Report, 0.26 million ha area is under shifting cultivation.

Frequent shifting from one land to the other for practicing Jhum has adversely affected the basic life support systems like vegetation and soil. The decline in the area under natural forest, the fragmentation of habitat, local disappearance of native species and invasion by exotic weeds plants are some of the ecological consequences of shifting agriculture. Due to shifting cultivation on steep slopes, down-stream siltation of the water bodies is apparent in many districts.

Two predominant forms of agriculture. Settled valley cultivation and adjoining upland cultivation

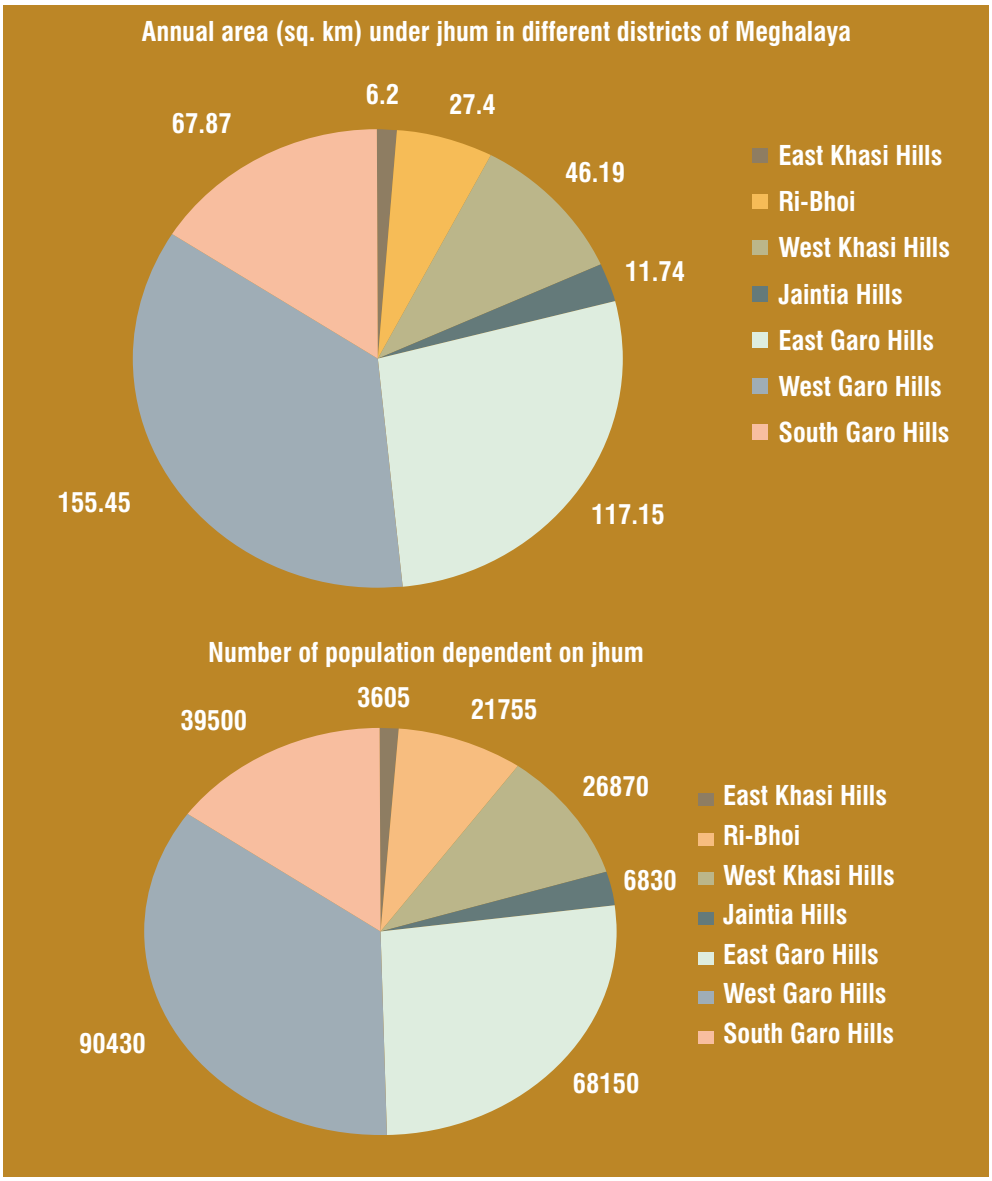


Fig. 15: Dependent population and area under shifting cultivation in Meghalaya

Green Issues

Response

Various attempts have been made by the Government to settle those who practice jhum. These schemes have, however, not yielded the desired results. Failure of the schemes led the National Commission of Agriculture to reformulate the schemes only after assessing their impact on forest. The practice of jhum could be minimized by :

A shifting cultivation plot under second year of cropping in Umden Village of Ri-Bhoi district.

(i) Providing employment opportunities and income generation on a regular basis through proper utilization of the land resources.

(ii) By encouraging cooperative efforts for carrying out forest-based activities, i.e. basket making, rope making, cane furniture making, processing of minor forest produce, honey collection, etc. have to be made commercially viable by providing proper marketing facilities. These will not only discourage people from practicing shifting cultivation but will also improve their economic condition.

(iii) By forming Village Forest Committees for the protection and development of the degraded forests. These committees may be able to generate employment opportunities during the lean season through various forestry and other land based activities.

(iv) Determining the population-supporting capacity (PSC) of the area may be one of the major aspects for checking the degradation of environment and depletion of resources. This should include not only the food production and land availability but also consider other factors which may increase the carrying capacity.

Table 7: DPSIR analysis for shifting cultivation

Driving force	Pressure	State	Impact	Response
• Population growth • Sustenance needs	Increasing demand on land, biodiversity, and water sources	Decrease in forest cover, Increase in degraded land area	Land degradation, Depletion of soil fertility, Decrease in productivity of natural ecosystems, Loss in crop productivity, Profuse weed growth including exotic species	Barren lands should be used for vegetable cultivation, Effective fallow manageent should be practiced, Tree plantation to be done on the degraded land. Proper land management, Improvement in land tenure system, Use of bamboo and other plants for income generation, Environmental education for masses, Protection of wildlife, and Formulation of state land use policy

Green Issues

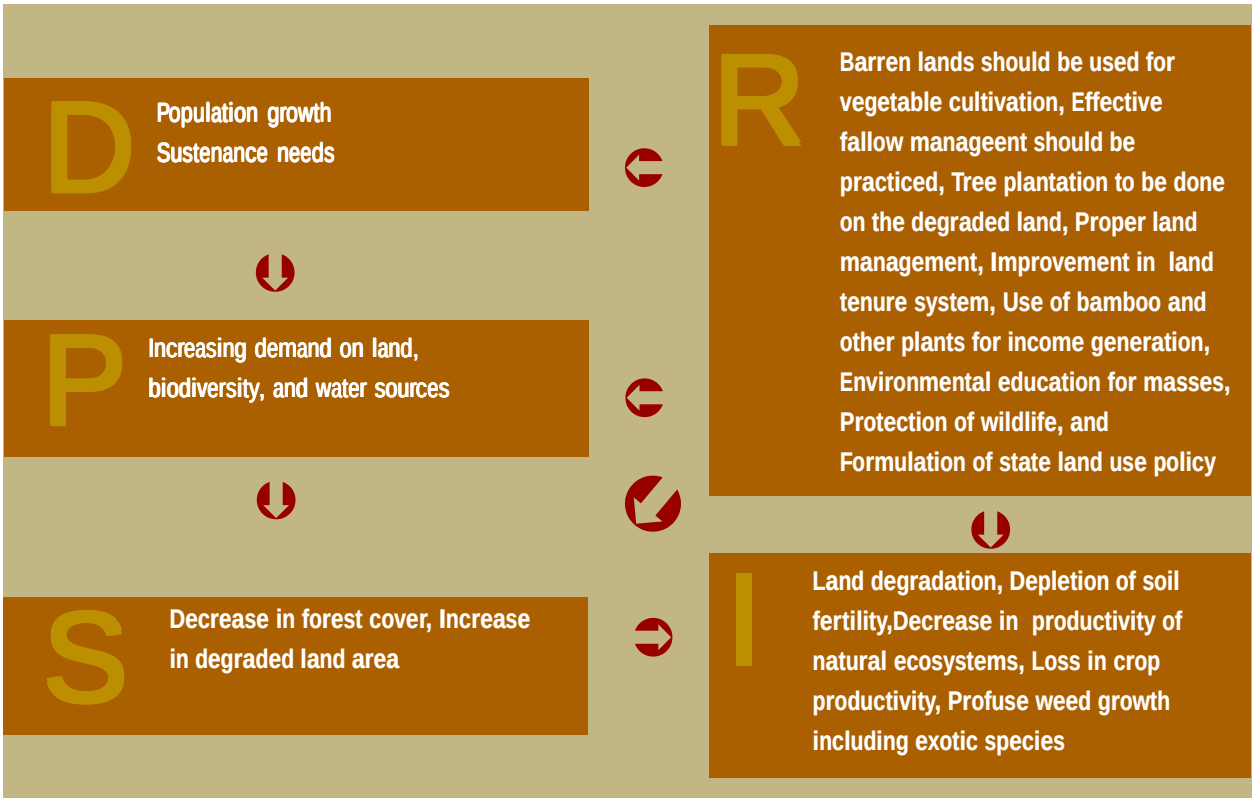


Figure 16: DPSIR analysis for shifting cultivation

Biodiversity Loss

Biodiversity Status

The state of Meghalaya is a part of Indo-Myanmar biogeospherical region, which is one of the mega biodiversity regions of the world. Nokrek Biosphere Reserve, Balphakram National Park, Nongkhyllem, Siju, and Baghmara Wildlife Sanctuaries and a large number of sacred groves found in different parts of the state are the main preserves of biodiversity (Table 9).

Table 9. Biodiversity rich areas in Meghalaya

Type	Location/Districts	Area (ha)
Balphakram National Park	South Garo Hills	22,000
Nokrek Biosphere Reserve	East, West and South Garo Hills	82,000
Nongkhyllem Wild Life Sanctuary	Ri-Bhoi	2,900
Siju Wild Life Sanctuary	South Garo Hills	5,18
Sacred groves	All over the state	10,000

Floral diversity

The floral diversity of Meghalaya is quite rich. It harbours about 3,128 species of flowering plants and contributes about 18% of the total flora of the country, including 1,237 endemic species (Khan et al 1997). Besides, a wide variety of wild cultivable plants, edible fruits, leafy vegetables and orchids are found in the natural forests of Meghalaya. About 40% (1237 species) of the total flora of the state is endemic (Khan et al 1997). The endemic and threatened species are mainly confined to the protected forests/sacred groves. The species endemic to Meghalaya include Aeschynanthes parasiticus, A. superba, Callicarpa psilocalyx, Camellia caduca, Citrus latipes, Ilex embeloides, Impatiens khasiana, I. laevigatum, Lindera latifolia, Nepenthes khasiana, Paramignya micrantha and Rubus khasianus (Balakrishnan 1981-1983). According to Takhtajan (1988), the flora of the Khasi and Jaintia hills is most richly saturated by eastern Asiatic elements, and the area is one of the most important centers of survival of the tertiary flora of eastern Asia.

***Nepenthes khasiana* (Pitcher plant) a rare and insectivorous plant, and also endemic to Meghalaya is in threat due to habitat loss.**

The species that were common some 20 to 30 years back are becoming rare due to overexploitation, deforestation and habitat destruction. Some fern species namely, *Dipteris wallichii* and *Cyathea gigantea* have become rare in Meghalaya. *Ilex embeloides, Styrax hookerii* and *Fissistigma verrucosum* that are considered extremely rare were collected from sacred grove recently after several decades (Upadhaya 2002, Jamir and Pandey 2003). Several orchid species such as *Dendrobium, Pleione,* and *Paphiopedilum* and *Vanda* having ornamental value are becoming rare in nature. *Podocarpus neriifolia, Cyathea gigantean, Ilex khasiana* and *Balanophora dioca and saprophytic orchids like Galeola falconeri, Epipogium roseum, Eulophia sanguinea* are becoming rare due to habitat destruction (Kataki 1986). *Nepenthes khasiana* which is one of the rare insectivorous plants, is reported only from a small pocket in Meghalaya. Rao and Haridasan (1983) have reported 54 rare and threatened plants, and Haridasan and Rao (1985-1987) have listed 44 rare dicotyledonous plants from Meghalaya.

A total of 546 vascular plants, were recorded from the five sacred groves of Jaintia Hills of Meghalaya (Table 10) (Upadhaya 2002, Jamir and Pandey 2003). Angiosperms with 515 species were the dominant component of the sacred grove flora.

Dipteris wallichii
Rare to Meghalaya

Balanophora dioca

Fissistigma verrucosum

Aeschynanthes superba
Endemic species

A few endemic and threatened category of species of Meghalaya

Table. 10. Taxonomic diversity of the sacred groves on Jaintia hills of Meghalaya.

Groups	Species				
	Sg1	Sg2	Sg3	Sg4	Sg5
Angiosperms	326	326	251	315	208
Gymnosperms	1	3	1	1	1
Pteridophytes	20	21	17	18	14
Total	**347**	**350**	**269**	**334**	**223**

Sg1 = Khloo Blai, Sg 2 = Khloo Poh Lyngdoh, Sg3 = Khloo Paiu Ram Pyrthai, Sg4 = Urkhla and Sg5 = Khloo Langdoh sacred groves

The floral elements from Sino-Himalayan, Myanmar-Malaysian, Malayan and to a lesser extent of peninsular India have been reported to be present in the groves of the state (Table 11).

Table 11. Species of different climatic zones and botanical regions present in sacred groves of Jaintia Hills

Tropical species	*Lithocarpus fenestrata, Elaeocarpus floribundus, Sarcosperma griffithii, Todallia asiatica and Cyathea* sp., *etc.*
Temperate species	*Rhododendron arboreum, Pinus kesiya, Ilex* sp., *Clematis* sp. *and Ranunculus* sp., *etc*
Sino-Himalayan species	*Polygala siberica, Corylopsis* sp., *Mahonia, Manglietia, Camellia, Eurya* sp., *and Anemone* sp., *etc.*
Burmese-Malayan species	*Vaccinium* sp., *Engelhardia spicata, Cinnamomum* sp., *Pittosporum* sp., *Litsea* sp., *Lasianthus* sp., *Gonionthalamus sesquipedalis, Balanophora dioca, Neillia thyrsiflora, Xantholis assamica and many Zingiberaceae, etc.*
Peninsular-India species	*Eurya japonica, Helecia nilagirica, Munronia pinnata, Schefflera wallichiana, etc.*

Sources: Puri (1960), Rao (1974) and Balakrishnan (1981- 83).

Primitive families like *Annonaceae, Rananculaceae, Piperaceae, Menispermaceae, Caryophyllaceae, Lauraceae, Myricaceae, Lazarbiadaceae* and primitive genera like *Sarcandra, Corylopsis and Myrica* (Takhtajan 1969, Balakrishnan 1981-1983 and Rao and Hajra 1986) are also present in the sacred groves (Table 12).

Table 12. Primitive flowering plants recorded in sacred groves of Jaintia Hills

Plant species	Family	Distribution
Manglietia sp.	Magnoliaceae	Eastern Himalayas.
Michelia sp.	Magnoliaceae	Temperate Himalayas and North-east India
Sarcandra glabra	Chloranthaceae	Indo-Malaya, North-east and southern India.
Corylopsis himalayana	Hamamelidaceae	North-east India
Myrica esculenta	Myricaceae	Himalaya, Myanmar, Indo-china, West and South China, Malayasia.
Houttuynia cordata	Saururaceae	Himalaya, Khasi hills, Manipur, Thailand, Indo-China.
Betula alnoides	Betulaceae	Temperate and subtropical Himalayas.

Sources: Takhtajan (1969), Rao and Hajra (1986), Balakrishnan (1981- 83).

Ninety-one species encountered in five sacred groves in Meghalaya are either rare, endangered in Meghalaya or endemic to northeast India or Meghalaya (Annexure V). Out of 91 species, 60 species are endemic to northeast India or eastern Himalayas and 51 are rare to Meghalaya (Fig. 17) and 26 species are endemic to Meghalaya.

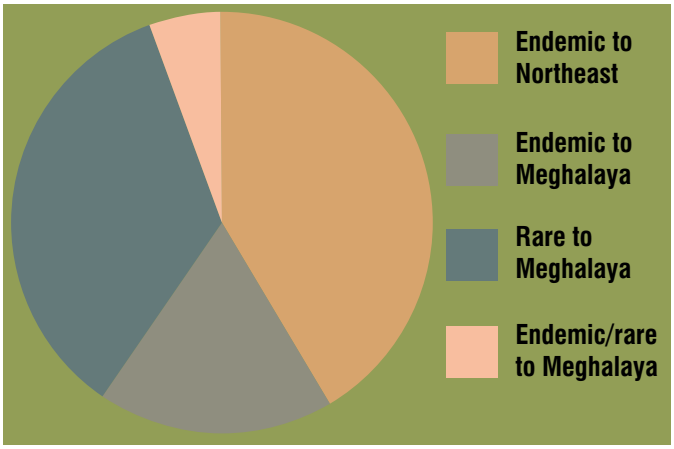


Fig. 17: Rare and endemic species of Jaintia Hills, Meghalaya

The high taxonomic diversity and the high concentration of endemic and rare species in Meghalaya is due to its geographical proximity to the species-rich Eastern Himalayas, South Central China, Myanmar and Malaya and the favourable climatic conditions of the area and protection afforded to these forests through ages on the grounds of religious belief and taboos.

Medicinal Plants

The state is rich in medicinal plant species diversity. The indigenous tribes in the state traditionally use plants for treatment of various ailments. Some of the medicinally important species reported from this state are *Acorus calamus, Asparagus racemosus, Garcinia cowa, Myrica esculenta, Panax pseudo-ginseng* and *Rauvlfia serpentina,* etc.

Faunal diversity

More than 110 mammal species are reported from the Meghalaya Forests, but none is endemic to the state. Some of the species of conservation importance include tiger (*Panthera tigris*), clouded leopard (*Pardofelis nebulosa*), Asian elephant (*Elephas maximus*), wild dog (*Cuon alpinus*), Malayan sun bear (*Ursus malayanus*), sloth bear (*Melursus ursinus*), large Indian civet (*Viverra zibetha*), Chinese pangolin (*Manis pentadactyla*), Indian pangolin (*Manis crassicaudata*), Assamese macaque (*Macaca assamensis*), bear macaque (*Macaca arctoides*), and capped leaf monkey (*Semnopithecus pileatus*). The tiger, clouded leopard, Asian elephant, Assamese macaque, bear macaque, capped leaf monkey, wild dog, sloth bear, and smooth-coated otter are threatened species (IUCN 2000). There are about 2,000 elephants in the Garo Hills and 500 in Jaintia Hills. The wild Buffaloes are also found in the forests of Meghalaya. Frogs and toads represent amphibians. Three types of reptiles - lizards, tortoises and snakes, are reported from the state. Several species of fishes and crabs are also found.

Two varieties of deer - Sambar and barking deer are found. In Sal forests, the red Jungle fowl are a common sight, but their population are dwindling fast. The large pied hornbill and the great Indian hornbill are also found in Meghalaya. The common green igeon is found in flocks in the forests. The black-necked stork is a common bird in marshland, beels, lakes and rivers. The most interesting rodents are flying squirrel, Malayan giant squirrel, Himalayan squirrel and Indian porcupine. The important civets are large Indian civets, small Indian civets and common palm civet or Toddy cat.

Problems relating to biodiversity conservation

(i) Land tenure systems

(ii) Clan-owned forests are mostly over-exploited and the District Council Acts, wherever applicable to these forests, are too weakly enforced.

(iii) Overexploitation of ornamental and medicinal plants and animal products.

(iv) Conversion of mixed forests into mono-specific forests and habitat destruction.

(v) Conversion of forests areas into agricultural lands.

(vi) Urbanization and Industrialization.

Urbanization

Meghalaya being a hilly state with variable climatic conditions, and geomorphic features is not conducive for the concentration of large urban population as observed in the plains. The hill cities and towns create hosts of environmental problems, which are unique to the area. Moreover, the hill cities are not well planned and they have grown primarily as trade or administrative centres.

During three decades of its existence Meghalaya has witnessed rapid urbanization in terms of growth of existing towns and cities, and development of new urban centres in different districts of the state. In Meghalaya, urbanization started in the early 1900's and the urban population which was about 2.5% of the state in 1901 rose to 20% in 2001. The increase in urban population was slow during 1901-1950, but it sharply increased during the next decade (1950-1960). Thereafter it has been rising over the years (Fig. 18). In comparison to the other northeastern states and India as a whole, the rate of urbanization has been slow in Meghalaya.

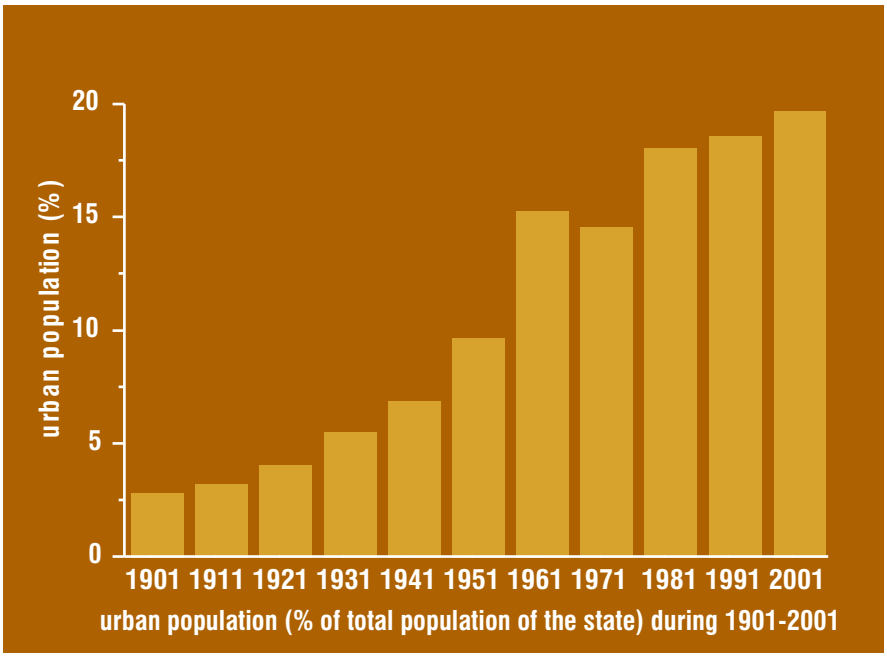


Fig. 18: Urban population growth in Meghalaya during 1901-2001

The slow pace of urbanization in Meghalaya is attributed to several factors such as difficult terrain, remoteness, poor communication, low economic activities even in the urban centres and poor development of infrastructure.

As per the standard classification of city, Shillong, the capital town with a population of more than 400,000, is the only Class I city in the state. Tura is the next populous city has class II city status. The other urban centers are much smaller in size in terms of population and they fall under class III, IV and V categories (Table 13). Shillong urban agglomeration has witnessed about 20% increase in population during 1991-2001. This is the lowest growth rate in comparison to other cities of the state. This highlights the fact that urbanization in the smaller towns of the state is faster than in Shillong. Within the Shillong city (urban agglomeration) area, Madan Riting is the fastest (85.82% increase) growing area followed by Pynthorumkhrah (61.58% increase). The Shillong municipality area is growing at the slowest rate (0.88%) (Table 13). The growth of the cities and towns of the state is largely due to migration from the surrounding rural areas and hinterlands of the respective urban centers and migration from the other states.

Table 13. Population and its growth rate (%) in the major urban centres of Meghalaya.

Urban centres	Population	Growth rate (1991-2001)
Class I (=100000 population)		
Shillong		
Urban agglomeration	267881	19.98
Municipality area	132876	0.88
Class II (=50000 population)		
Tura	58391	26.76
Class III (=20000 population)		
Jowai	25023	21.46
Nongstoin	22,003	53.45
Pynthorumkhrah	22108	61.58
Nongthymmai	34,209	27.00
Mawlai	38241	23.50
Class IV (=10000 population)		
Madan Riting	16700	85.82
Shillong Cantonment	12385	11.82
Cherrapunjee	11086	42.55
Williamnagar	18251	52.04
Resubelpara	17652	-
Mairang	11517	-
Nongmunsong	11362	-
Nongpoh	13165	-
Class V (<10000 population)		
Bagmara	8643	46.64

Sources: Census of India, 2001.

The urbanization pattern has witnessed a marked change during the decade 1991-2001 (Fig. 19).

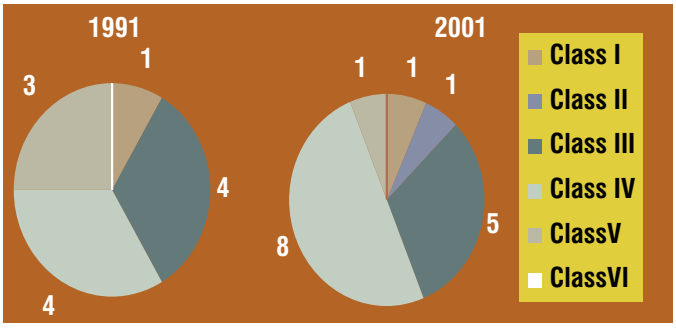


Fig. 19: Number of towns of classified by size in Meghalaya in 1991 and 2001

In 1991 there were 12 towns in Meghalaya. The number rose to 16 by the year 2001. There was no addition in class I town, number of class III town decreased from 3 to 1, but the number of small town (class IV) has doubled during this period. The class III and IV towns together support major portion of urban population in the state. Majority of towns is either medium (class II, III) or small (class IV and V). These are expanding in unplanned manner and may create environmental problems in near future. There has been a significant increase in the population of medium towns between 1991and 2001. During the same period population in class I town has decreased (Table 14).

Table 14. Distribution of urban population (%) in different classes of towns of Meghalaya

Yrs.	State	Cities	Medium Towns			Small Towns			
		Class I	Class II	Class III	Total	Class IV	Class V	Class VI	Total
1991	Meghalaya	39.71	0.00	37.57	37.57	15.73	6.98	0.00	22.71
2001		29.36	12.90	31.28	44.18	24.55	1.91	0.00	26.46
1991	Northeast	24.79	8.42	26.73	35.15	21.56	12.35	6.21	40.11
2001		27.31	6.58	30.39	36.97	21.86	9.96	3.90	35.72

The East Khasi hills district has the highest urban population (277,967) followed in decreasing order by West Garo hills, East Garo hills, West Khasi hills, Jaintia hills and Ri Bhoi district. South Garo hills district with an urban population of 8643 is the least urbanized (Fig. 20).

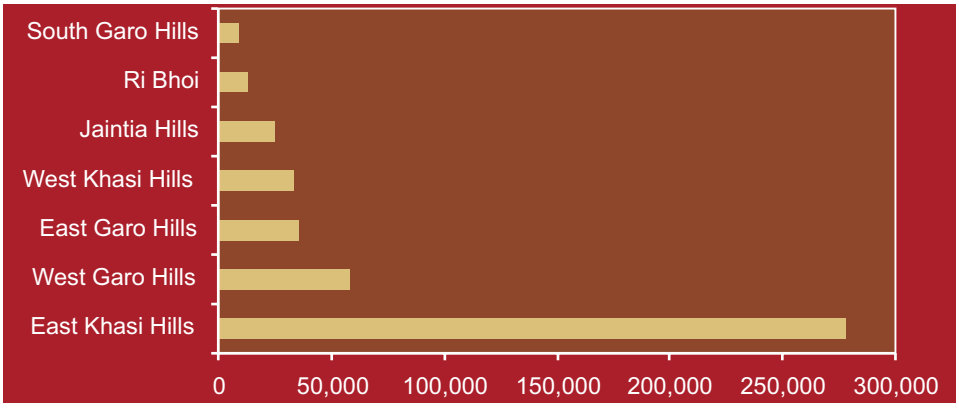


Fig. 20: Urban population in different districts of Meghalaya

Based on the level of urbanization, the districts of the state fall into three categories viz., high urbanization (40-50%), low urbanization (10-20%) and very low urbanization (0-10%) (Table 15).

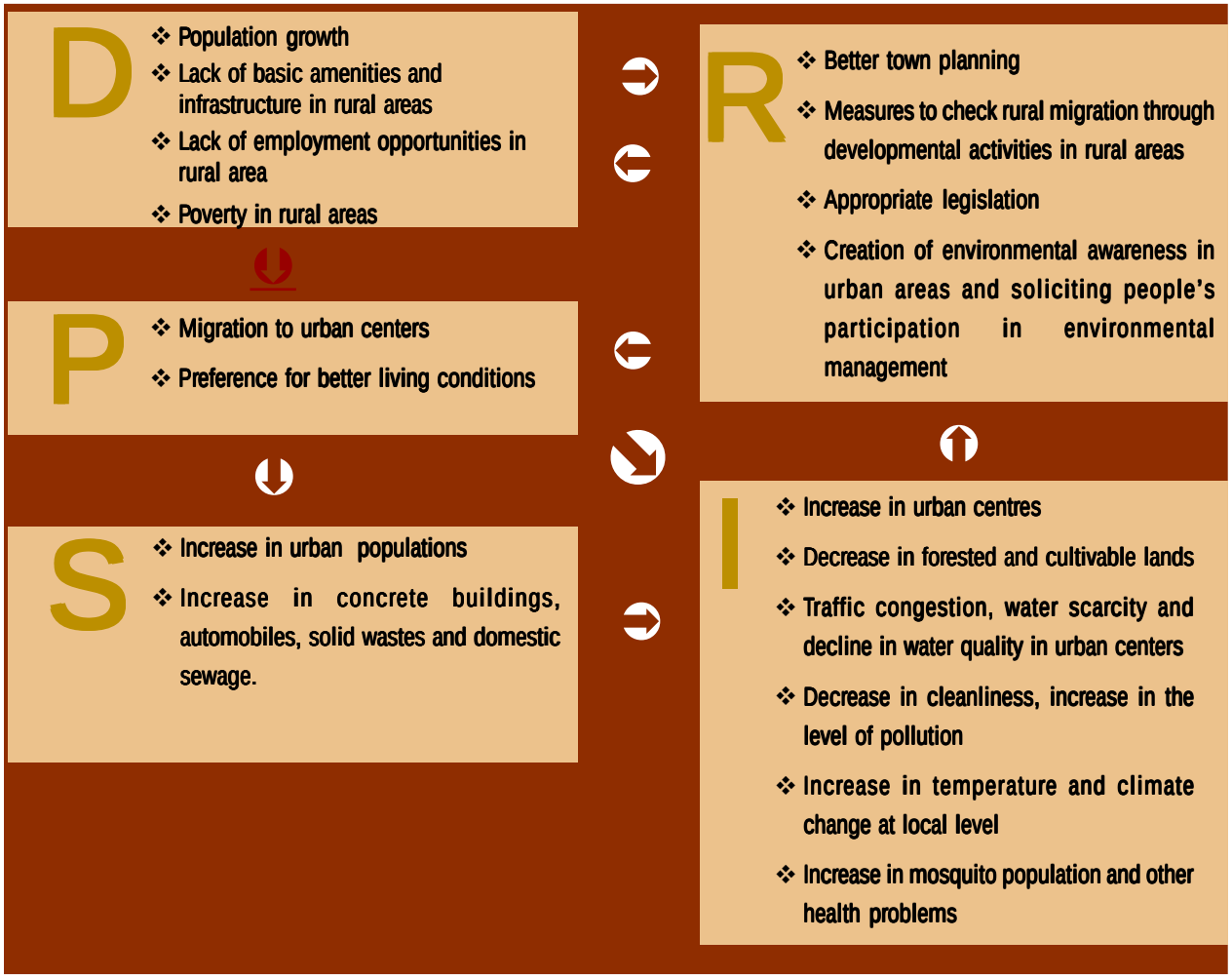
Table 15. Levels of urbanization in different districts of Meghalaya.

Districts	Levels of urbanization (%)
East Khasi hills	40-50
East Garo hills, West Garo hills, West Khasi hills	10-20
Jainta Hills, Ri Bhoi, South Garo Hills,	0-10

(Source: Census of India, Provisional Population Totals, 2001)

The DPSIR analysis for urbanization has been done in Figure 21.

Figure 21: DPSIR analysis for Urbanization



Mining

The state of Meghalaya is rich in mineral resources. The major minerals present in the state are coal, limestone, clay and sillimanite. Besides, ores of iron, uranium, copper, granites, gold etc. are also found in the state (Fig. 22). On an average, the annual revenue income of the state from these minerals is about Rs. 40 crore. During the year 1997-98, the total revenue from mineral sector was Rs. 3980.32 lakh.

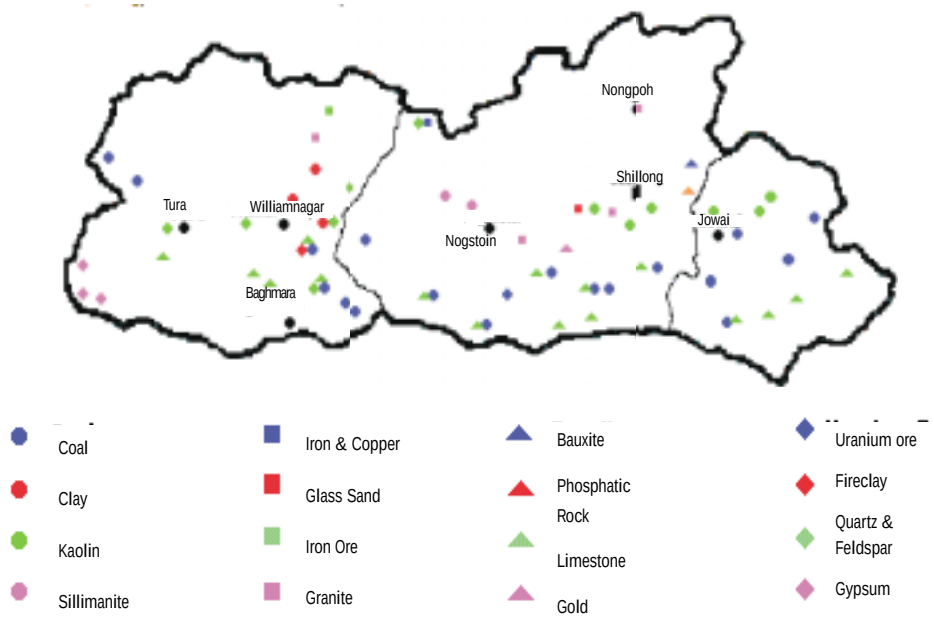


Fig 22: Distribution of major minerals in Meghalaya

(Source: Meghalaya State web site)

Coal

Meghalaya has an estimated coal reserve of 559 million tones, which are spread over in an area of 213.9 sq. km covering approximately 1% of the total geographical area of the state. The Garo Hills district has the highest coal reserve of 390 million tones, followed by West Khasi Hills (98 million tones), Jaintia Hills (39 million tones) and East Khasi Hills districts (31 million tones) (Fig. 23). Important coal-bearing areas of the state are presented in Table 16.

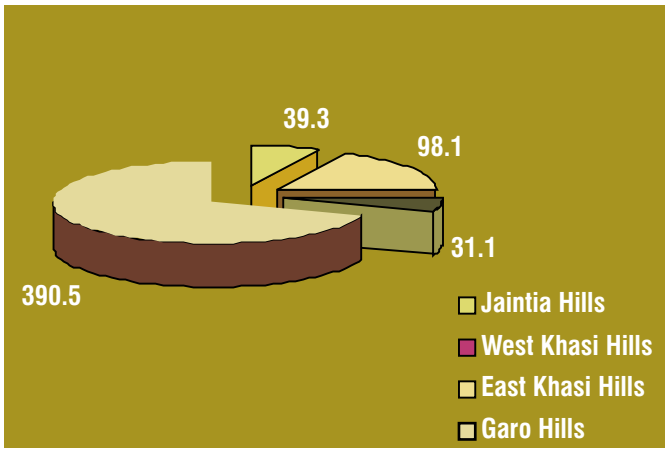


Fig. 23: Estimated coal deposits in the state.

Large-scale coal mining in the unorganized sector in Jaintia Hills is affecting the landscape level processes

Table 16: Estimated coal reserve in different districts of Meghalaya.

Location	Area (sq. km)	Reserve (in million tones)
Khasi Hills		
Laitryngew.	31	2.738
Cherrapunji	36	19. 0
Laitduh	0.12	0.12
Mawbehlarkar	0.10	0.12
Mawsynram Rongsakham, Jathang and Mawsngi area	Coal seams with average thickness of 2.4 m	0.30
Lumdidom	0.2	0.20
Langrin	Four seams with thickness of 0.6, 1.21, 0.9 and 1.10 m	97.61
Pynursla- Iyngkyrdem	2	0.50
Mawlong- Shella-Ishamati	8	9.0
Garo Hills		
West Darranggiri	47	127
Siju	Coal seam about 11 km in strike length	125
Pendengru-Balphakram	13	107
Jaintia Hills		
Bapung	3 coal seams cover an area of 46	33.66
Lakadong, Umlatdoh	3	1.5
Sutnga	0.16	0.65
Jarain	2.8	1.1
Musiang Lamare		2.31
Loksi		3.6

(Source: neidatabank@hub.nic.in)

Most of the coal is of sub-bituminous type with low ash and high sulphur contents and has high calorific value and hydrogen content (1.5-2.8%). Since the industrial demand within the state is quite low, a major portion of the coal produced in the state is exported to Bangladesh and outside the north-eastern region. The local industries using the coal include, cement plants, lime kilns, brick-burning and pottery industries.

Although mining of coal started during British period, its production on regular basis started in the early 1970's. Initially the production was inconsistent and was very low (< 100 MT) till the year 1980. There was a phenomenal increase in production after 1980, which peaked in the year 1999 (>4000 MT) (Fig. 24).

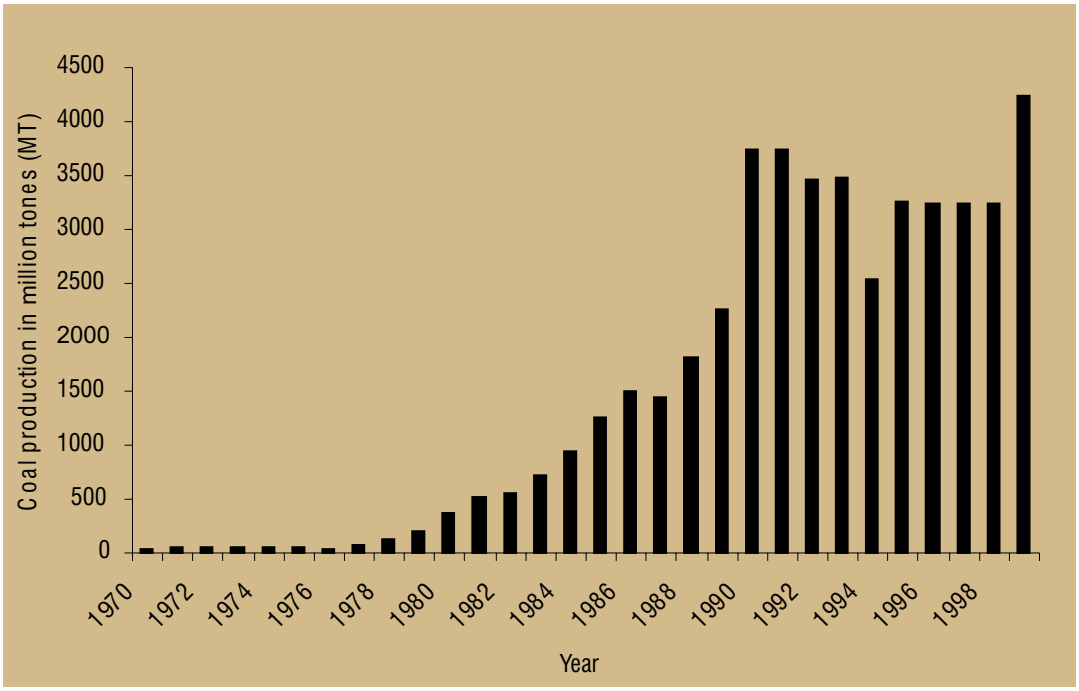


Fig. 24: Coal Production in Meghalaya between 1970-1999

(Source: Tripathi et al. 1996; Directorate of Economics and Statistics, 2000)

Maximum coal is produced from Jaintia hills district (2786 MT), followed by East Khasi Hills and Garo Hills district (Fig. 25). Among all the coalfields, Bapung area in Jaintia hills is the most extensively exploited area in the state.

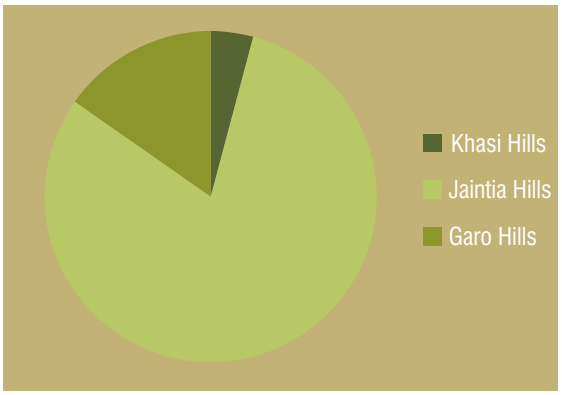


Fig. 25: District-wise coal production (million tones) in Meghalaya during 1991.

Limestone

It is the second most important mineral exploited in the state. Its deposit extends from the southern part of the Garo hills to Jaintia hills through Khasi hills. The major deposits of the limestone are found in Cherrapunjee and Shella-Bholagang area in Khasi hills, Nongkhlieh and Lumshong in Jaintia hills and Darrangiri-Era and Anig-Siju in Garo hills (Table 17). The total estimated reserves of the limestone in the state are 2462.5 million tones. The maximum reserve is in Jaintia hills (55%), followed by Khasi hills (38%) and only about 7% are found in the Garo hills (Tripathi et al. 1996).

Table 17: Estimated limestone reserves (million tones) in Meghalaya

Location	Estimated reserve	Grade
Khasi Hills		
Cherrapunji	40	Cement
Shella-Bholagang	900	Cement
Garo Hills		
Darranggiri	5.5	Flux
Anig-Siju	165	Cement
Jaintia Hills		
Nongkhlieh	700	Cement
Lumshong	652	Flux

Source: Basic statistics of northeastern region, 1982)

The annual limestone production increased from 65 MT in 1970 to 389 MT in 1999 (Fig. 26). The annual production varied from year to year between 1970 and 1990 without showing any consistent progressive trend. But after 1990 there has been a progressive increase in the extraction of limestone in the state.

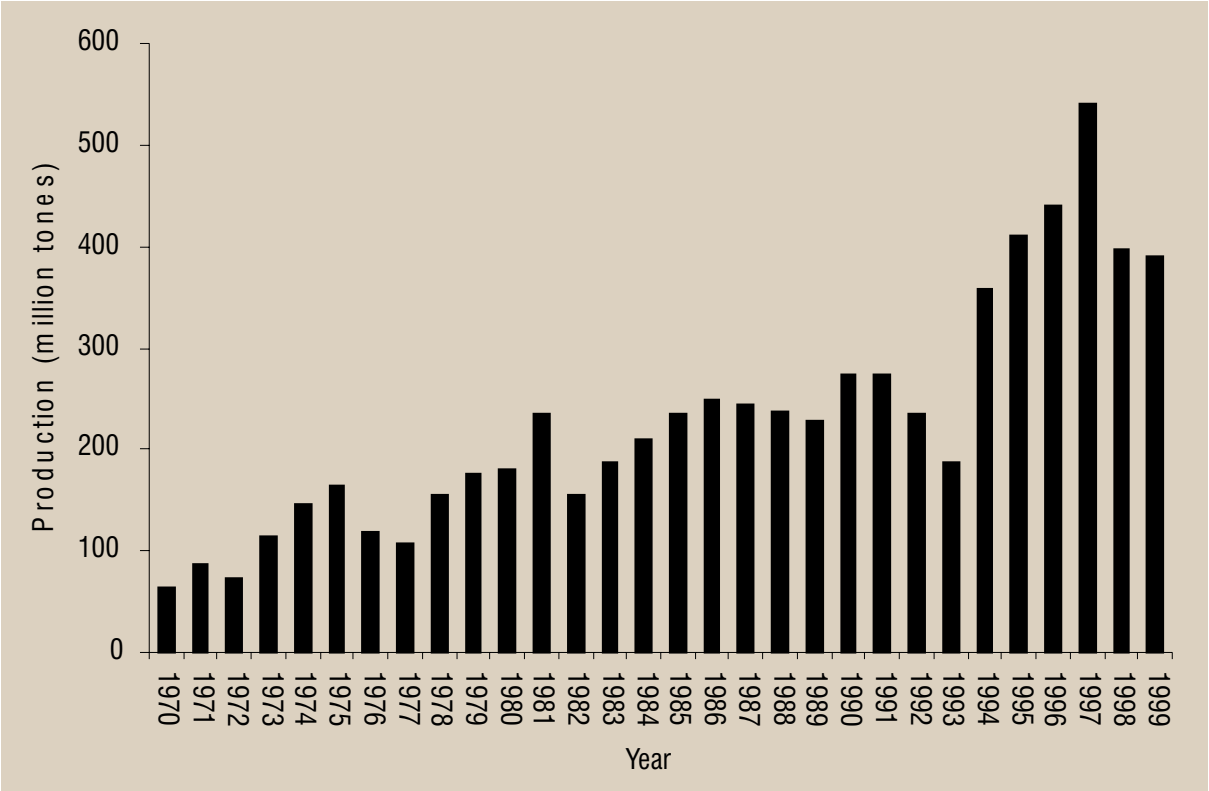


Fig. 26: Limestone production in Meghalaya during 1970-1999.

Brown Issues

Sillimanite

One of the best Sillimanite deposits of the world is found in the Sonapahar region of West Khasi Hills. Geologically, these Sillimanite deposits occur in association with corundum, within the quartz- Sillimanite schist that forms a broad band that can be traced discontinuously over the area. The high alumina-content of the rock makes this mineral a natural refractory mineral of great commercial value. The total inferred reserve of Sillimanite in Sonapahar and Mawpomblang is estimated at 0.045 million tones.

Glass-Sand

Glass-Sand or Silica-Sand occurs in Laitryngew, Umstew and Kreit in Khasi Hills and Tura in Garo Hills. The sand contains a slightly high proportion of iron, which is not suitable for the production of first grade glassware. However, bottles or sheet glasses may be manufactured from these sands where colour is not the sole consideration. The Silica-Sand can also be utilised in the manufacture of sodium silicate. The total reserve of Glass-Sand in Meghalaya is of the order of 3 million tones.

Granite

Deposits of multi-coloured Granite suitable for use as dimensional and decorative stones have been located in the area around Nongpoh, Mylliem and Mawkyrwat as well as in the area around Mendipathar - Songsak road. The possible reserve of about 25 million cubic metres may be present in the area (Directorate of Mineral Resources, Nongpoh).

Gypsum

Gypsum, one of the ingredients in cement manufacture is reported to occur in Mohendraganj and Harigaon in West Garo Hills. It occurs as minute crystals in the gypsiferous shale. The concentration of Gypsum in shale is 0.07%. Since the concentration of Gypsum in the host rock is uneconomic, detailed study on its reserve has not been carried out.

Gold

Occurrence of Gold in a Shear Zone has been reported from Tyrsad, Khasi Hills. The Gold is associated with Arseno-Pyrite and Pyrite. The maximum thickness of gold-bearing rock recorded in a bore-hole is 2.90m. In the core samples, the gold-content varies from 0.8 g/ton to 62 g/ton, which is economically nonviable.

Uranium

Uranium and some other radio-active minerals are found in different parts of the state. The Uranium deposit located at Domiasiat in West Khasi Hills district is of higher grade compared to a deposit presently been exploited in the country.

Iron-Ores

Banded-haematite quarzites are found in association with the gneissic complex at Aradonga, Athiabari and Nishangram areas of Meghalaya.

DPSIR analysis has been done in Table 18.

Brown Issues

Table 18: DPSIR analysis for mining

Driving force	Pressure	State	Impact	Response
• Industrial development in Meghalaya • Demand of Meghalaya coal by other states and neighbouring country • Income generation	Vegetation	Loss of vegetal cover and biodiversity	Destruction of natural forest	Improved technology for excavation and better management for storage and transport
	Land	Degradation of land due to sinking of abandoned mines	Development of degraded plant communities like grasslands and weed infested landscape	Proper regulation for mining operations to check environmental degradation and rehabilitation of degraded landscape
	Soil	Soil erosion and pollution	Land degradation and habitat destruction	Restoration of degraded land through forestry and other methods
	Water	Water scarcity and pollution	Loss in soil fertility	Develop better drainage system for the disposal of mine discharge
			Qualitative change in water	Organize awareness programmes to educate the people inhabiting mine affected areas about the environmental hazards associated with mining
			Socio-economic changes in traditional tribal society	
			Health hazards	

Blue Issues

Water pollution

Meghalaya is endowed with abundant water resource in the forms of springs, streams, rivers and lakes, distributed throughout the state. With the increasing human population and growing urbanization and industrialization most of these water bodies are being gradually polluted. The consumption of polluted water causes various kinds of diseases and poses threat to human health. Therefore, monitoring the quality of water and taking necessary measures to improve the same assumes a great significance. However, the information on the quality of water in various water bodies of Meghalaya is rather meagre.

Driving Force

The fresh water bodies are being adversely affected mainly by deforestation, shifting cultivation and urbanization. High rainfall and hilly topography have further compounded the problem. Fine particles of coal, sand, mud and other mineral particles deposited at the bottom of the water bodies destroy the benthic habitat and reduce availability of oxygen for benthic animals. Acidic mines drainage containing heavy metals and coal and sand particles originating from mines and spoils flows into the nearby stream or river and pollute it. Continuously increasing human population and lack of proper sanitation are responsible for organic enrichment of water bodies of the area.

Pressure

During rainy season silt load in the rivers and streams is increased several fold as they pass through the deforested areas. Deforestation has led to drying of several perennial springs and streams. A case in point, is that of Cherrapunjee which receives an average of 10,000 mm of rainfall annually but its 30,000 inhabitants suffer from water scarcity. Deforestation and soil erosion coupled with lack of water retention facilities have contributed to serious water scarcity problem during post-rainy months of the year in the area.

Coal mine seepage is another major cause of pollution of water bodies in the mine affected areas of the state. Rapid expansion of Shillong, the capital town of the state and development of other urban centers without proper sewage systems and sewage treatment facilities has become the major cause of deterioration of water quality around urban centers.

State

The pollution level and quality of water of 15 rivers and 5 lakes of Meghalaya have been assessed. The rivers whose waters have been analysed are Umshyrpi, Umkhrah, Umtru, Kyrhokhla, Dagol, Ganol, Simsang, Rongra, Weisohlam, Phodthra, Wah Riat, Umkhen, Umbhang, Kreum and Amlarem are the lakes for which data have been collected include Ward's Lake, Umiam, Thadlaskein, Chitmarang and Tasek. The parameters like pH, turbidity, conductivity, total and dissolved solids, hardness, alkalinity, chlorides, sulphate, iron, nitrite, nitrate, ammonium, total nitrogen, dissolved oxygen, biochemical and chemical oxygen demand, and total bacterial population as well as population of faecal coliform bacteria were considered to assess the quality of waters of lakes and rivers in the state.

Measurement of pH is one of the most important and frequently used tests in water chemistry. It indicates whether the water is acidic(< pH 7) or alkaline (>pH 7). Very low or very high pH is not favourable for the growth of organisms and is not fit for animal and human consumption.

The pH of river water in Meghalaya varies from acidic to alkaline. The water of Kyrhokhla, Kreum and Amlarem rivers is acidic while and pH in the case of Kreum river is as low as 4.8. The water of Gonal river is alkaline (pH 8.4), while water of other rivers is either slightly acidic or slightly alkaline in reaction. The pH of lake water varies from slightly acidic to slightly alkaline (pH 6.5-7.5) (Table 19). In coal mining areas water in streams and submerged paddy fields is slightly acidic to highly acidic in nature.

Fine particles of coal and other minerals leads to contamination of water bodies

Table 19. Mean pH, turbidity, solid particles and specific conductivity of river/lake water in Meghalaya

River	pH	Turbidity (NTV)	Total Solids (mg/l)	Dissolved Solids (mg/l)	Specific Conductivity (umho/ml)
Umshyrpi	7.4	26.0	228.0	-	134.0
Umkhrah	7.3	26.5	265.0	-	183.0
Umtru	7.4	19.2	198.0	32.0	142.0
Kyrhokhla	5.6	6.8	212.0	178.0	24.0
Dagol	7.6	2.5	274.0	-	60.0
Ganol	8.4	25.0	336.0	-	64.0
Simsang	7.8	2.2	172.0	-	62.0
Rongra	7.4	4.0	187.0	-	60.0
Weisohlam	7.0	4.0	-	-	10.0
Phodthra	7.1	13.0	-	-	11.0
Wah Rait	7.1	10.0	60.0	-	18.0
Umkhen	6.8	768.0	2800.0	2660.0	12.0
Umbhang	6.9	9.6	80.0	38.0	600.0
Kreum	4.8	0.8	-	-	690.0
Amlarem	5.5	2.8	-	-	127.0
Lake	**pH**	**Turbidity (NTV)**	**Total Solids (mg/l)**	**Dissolved Solids (mg/l)**	**Specific Conductivity (umho/ml)**
Ward's lake	7.3	10.4	114.0	62.0	84.0
Umiam	7.3	8.0	114.0	50.0	73.0
Thadlaskein	7.5	7.5	50.0	30.0	40.0
Chitmarag	6.8	4.0	165.0	60.0	36.0
Tasek	6.5	8.0	148.0	34.0	47.0

- indicates data not available.

Turbidity and total Dissolved Solids

The turbidity in water is caused by suspended particulate matter like inorganic and organic substances and planktonic organisms. The inorganic substances mostly include clay, silt and sand particles, while organic fraction includes bacteria, algae, and plant and animal debris. Turbidity reduces productivity of water bodies by reducing light penetration. The turbid water is unhygienic. In Meghalaya, the river as well as lake waters are generally very clear except in the Umkhen river where turbidity is as high as 768 NTV. High turbidity in this river is due to high quantity of total solids (2800mg/l) and total dissolved solids (2660 mg/l) in the water of this river (Table 19). In other rivers the amount of total solid ranges from 60 to 336 mg/l and dissolved solids fom 32 to 178 mg/l. The total solids and dissolved solids in the lake water range from 50 to 165mg/l and 30 to 62 mg/l, respectively (Table 19).

Specific conductivity

It is an important index of biological productivity and a valuable measure of ionic concentration in various aquatic environs. The specific conductivity is low (10-64 umho/ml) in Kyrhokhla, Dagol, Ganol, Simsang, Rongra, Weisohlam, Rodthra, Wah Riat and

Umkhen rivers, moderate (127-183 umho/ml) in Umshyrphi, Umkhrah, Umtru and Amlarem rivers and very high (600-690 umho/ml) in Umbhanga and Kreum rivers. The specific conductivity of the lake waters ranges from 36 to 84 umho/ml (Table 19).

Hardness

Water is called hard when it does not produce lather with soap. High concentration of calcium, magnesium and sodium ions and their bicarbonates causes hardness of water. The data for a large number of rivers and lakes show that the water of Meghalaya is soft (Table 20).

Table 20. Hardness and total alkalinity of water bodies of Meghalaya

River/lake	Hardness (mg/l)	Alkalinity (mg/l)
Rivers		
Umshyrpi	48.2	46.0
Umkhrah	55.2	100.8
Umtru	24.0	24.0
Kyrhokhla	14.0	14.0
Dagol	30.6	24.0
Ganol	28.4	28.0
Simsang	28.6	24.0
Rongra	30.8	30.0
Weisohlam	14.7	17.0
Phodthra	14.7	17.0
Wah Rait	12.6	15.0
Umkhen	14.2	12.0
Umbhang	28.8	34.0
Kreum	41.6	87.5
Amlarem	0.0	10.0
Lakes		
Ward's lake	52.0	33.0
Umiam	54.0	52.6
Thadlaskein	32.0	32.0
Chitmarag	15.4	14.0
Tasek	21.0	20.0

Total Alkalinity

It is an index of biological productivity of aquatic system. Presence of carbonate, bicarbonate and hydroxyl ions in water influences its alkalinity. Concentration of these ions, which serves as the measure of alkalinity, varies between 10.0 and 100.8 mg/l in the rivers of Meghalaya, whereas the alkalinity in lake waters varies from 14 to 52.6 mg/l (Table 20).

Nitrogen

Nitrogen is one of the major essential nutrients required for the normal growth of aquatic plants and animals. Its deficiency adversely affects the biological productivity of water body. In water it is found in both inorganic and organic forms. The inorganic nitrogen (nitrite, nitrate and ammonium) is derieved from the nitrogeneous materials such as proteins, peptides and amino acids. Aquatic plants use inorganic forms of nitrogen for their growth and development. However, increase in the concentration of nitrite and ammonium ions beyond a particular limit becomes toxic to the growth of aquatic plants.

The nitrite nitrogen concentration in the river and lake water is insufficient (Table 21). Nitrate concentration is also very low, sometimes even below the detection level, in most of the rivers and lakes. The rivers Umkhrah and Kreum, however, have 9 and 10 mg/l nitrate, respectively (Table 21). Highest concentration of ammonium (18.0 mg/l) is found in the river Kreum. Total nitrogen concentration which includes both organic as well as inorganic forms, is low in all rivers and lakes of Meghalaya.

Table 21: Concentration (mg/l) of nitrogen (nitrite, nitrate, ammonium and total Kjeldahl nitrogen), chloride, sulphate and iron in the water of different rivers and lakes of Meghalaya

River/lake	Nitrite	Nitrate	Ammonium	Total-N	Chloride	Sulphate	Iron
Rivers							
Umshyrpi	1.5	8.0	-	-	121.4	-	1.20
Umkhrah	0.4	9.0	-	-	142.8	16.0	1.40
Umtru	-	-	4.0	3.8	20.1	13.2	0.50
Kyrhokhla	-	-	2.0	2.4	33.5	40.5	2.00
Dagol	BDL	0.3	-	-	9.1	4.8	0.06
Ganol	BDL	0.3	-	-	6.7	9.3	0.10
Simsang	BDL	0.2	-	-	6.6	5.3	0.20
Rongra	BDL	0.4	-	-	5.3	6.3	0.10
Weisohlam	-	0.1	-	-	7.4	6.7	1.20
Phodthra	BDL	0.2	-	-	8.7	5.5	0.70
Wah Rait	-	0.2	-	-	8.0	5.0	0.70
Umkhen	1.0	0.3	-	-	8.0	5.0	0.70
Umbhang	BDL	BDL	-	-	29.6	-	1.20
Kreum	BDL	10.0	18.0	1.0	79.1	2191.7	7.00
Amlarem	BDL	0.8	0.2	1.2	22.7	300.0	0.80
Lakes							
Ward's lake	BDL	-	2.4	3.5	30.6	4.5	0.20
Umiam	BDL	BDL	1.0	6.6	30.6	1.7	0.20
Thadlaskein	BDL	BDL	0.7	1.2	23.9	1.5	0.30
Chitmarag	BDL	0.6	-	-	6.7	14.0	2.00
Tasek	BDL	0.3	-	-	8.0	8.2	0.70

- Data not available, BDL- Below detection level

Chloride

It is regarded as a valuable indicator of water quality. It plays an important role in photosynthesis. In the river waters of Meghalaya the chloride concentration varies widely from 5.3 to 142.8 mg/l, however, in lake waters the range is narrow (6.7-30.6 mg/l) (Table 22). The rivere Umshyrpi (121.4 mg/l) and Umkhrah (142.8 mg/l) have much higher chloride content than other rivers and the lakes.

Sulphate

It is one of the important water pollutants. It causes acidity in water and directly affects the growth of aquatic flora and fauna. The sulphate concentration varies widely in rivers of Meghalaya. Out of the 13 rivers, 10 have low sulphate content, while in other three viz., Kyrhokhla, Amlarem and Kreum, the sulphate content is very high. The sulphate content is 40 mg/l in Kyrhokhla, 300mg/l in Amlarem and 2191.7 mg/l in Kreum river. In the latter case it has reached the toxic level. The lake water in the state is, however, low in sulphate content with varies from 1.5 to 14.0 mg/l in different lakes (Table 22).

Iron

Iron in trace amount is favourable for the growth of aquatic life, but its high concentration causes adverse effects on the organisms. The iron concentration is very low in all the rivers and lakes, except Kreum which is highly contaminated (7.0 mg/l) (Table 22).

Dissolved Oxygen

Dissolved oxygen is the source of oxygen for respiration of all aquatic organisms. Its level in natural water depends on physical and chemical properties of water and biological activities in the water bodies. The concentration of dissolved oxygen in water provides an important clue to the pollution level in water bodies. The dissolved oxygen varies from 5.1-11.0 mg/l in different rivers of Meghalaya. The river Amlarem contains the lowest amount of dissolved oxygen (5.1 mg/l) followed by Umkhem river. Umtru river contains maximum dissolved oxygen. The amount of dissolved oxygen in the lakes of Meghalaya is within the normal range (Table 22).

B.O.D. and C.O.D.

The amount of oxygen necessary for the oxidative decomposition of a material by organisms is known as Biochemical Oxygen Demand (B.O.D.) of natural water. Pure or unpolluted water has low (<5) B.O.D. while polluted water has high (>10) B.O.D. Besides B.O.D, C.O.D. i.e., Chemical Oxygen Demand is also used as a measure of pollution in water. Among the rivers, Umkhrah river water has highest B.O.D. (45.7 mg/l) and C.O.D. (162 mg/l) followed by Umshyrpi (151.6 mg/l). Among the lakes Chitmarag lake has high B.O.D. (43 mg/l) and C.O.D. (61.2 mg/l). In other rivers and lakes oxygen demand is within the normal limits (Table 22).

Coliform Bacteria

All bacteria that produce colony with a golden green metallic lustre within 24 hours of incubation on a suitable medium are considered to be the members of coliform group. The coliform group comprises all aerobic, facultative aerobic, gram negative, non-spore forming and rod shaped bacteria. Their quantitative estimation is a useful measure of water pollution. In water they may be measured as total coliform or faecal coliform. The faecal coliform test differentiates between coliforms of faecal origin (intestine of warm blooded animals) and coliforms from other sources. The waters of the Umtru and Kyrhokhla river and that of the Thadlaskein lake contain insignificant number of total and faecal coliforms.

The rivers Umshyrpi, Ganol, Simsang, Rongra, Weisohlam, Phodthra, Wah Riat and Umkhen contain very high number of total as well as faecal coliform bacteria. In these rivers the most probable number (MPN) of total coliform bacteria varies from 1600 to 9000 per ml of water (Table 22). Among the lakes, the Ward's lake is the most polluted followed by the Umiam lake. Other lakes contain relatively smaller number of coliforms (Table 22).

Table 22: Concentration of dissolved oxygen, biochemical and chemical oxygen demand (i.e. B.O.D and C.O.D) and most probable number (MPN) of coliform bacteria in the waters of different rivers and lakes of Meghalaya.

River/lake	Dissolved oxygen	B.O.D (mg/l)	C.O.D (mg/l)	Total coliform (MNP/ml)	Faecal coliform (MPN/ml)
Rivers					
Umshyrpi	7.0	-	151.6	2400	2300
Umkhrah	6.8	45.7	162.0	2400	2
Umtru	11.0	4.0	9.6	10	2
Kyrhokhla	7.0	1.8	4.8	6	0
Dagol	6.7	2.6	12.3	350	9
River/lake	**Dissolved oxygen**	**B.O.D (mg/l)**	**C.O.D (mg/l)**	**Total coliform (MNP/ml)**	**Faecal coliform (MPN/ml)**
Ganol	7.8	3.9	14.4	2400	1600
Simsang	6.2	4.0	14.4	2400	700
Rongra	6.5	4.5	18.0	9000	5000
Weisohlam	5.9	0.2	5.1	2400	1600
Phodthra	6.1	0.2	5.1	1600	1600
Wah Rait	5.9	0.5	13.6	2400	2400
Umkhen	5.4	0.5	13.6	2400	350
Umbhang	-	-	5.6	-	-
Kreum	5.6	0.4	1.4	-	-
Amlarem	5.1	1.2	-	-	-
Lakes					
Ward's lake	9.9	5.0	12.4	1600	140
Umiam	9.8	3.0	12.0	540	130
Thadlaskein	8.7	6.0	12.8	7	4
Chitmarag	5.6	43.0	61.2	160	-
Tasek	5.8	4.4	20.0	300	-

It is evident from the analysis of 20 parameters of water quality that most of the rivers of Meghalaya are polluted. The pollution level in some of them has reached the toxic level, making their waters unfit for human use. The rivers Umkhen, Kreum, Amlarem, Umshyrpi, Umkhrah, Kyrhokhla, Wah Riat and Rongra are polluted with one pollutant or the other, while other rivers like Umtru, Dagol, Ganol, Umbhanga, Rodhtra and Simsang are relatively less polluted. The water of Kreum, Amlarem and Kyrhokhola is highly acidic and contain

high levels of sulphate. The water in Umkhen river is loaded with suspended and dissolved solids, which makes it highly turbid. The dissolved oxygen is low and coliform bacteria abounds in this river. Umshypri and Umkhrah rivers are also loaded with solid particles and have large number of coliform bacteria. Biological oxygen demand too is high in these two rivers. The rivers Rongra, Wah Riat, Weisohlam, Ganol and Simsang are highly contaminated with coliform bacteria, mostly of faecal origin. The lakes are relatively less polluted and the quality of water is better than the rivers. However, the Ward's lake is highly contaminated with coliform bacteria followed by Umiam lake. Other lakes like Thadlaskein, Chitmarag and Tasek are unpolluted.

Further, the data on the parameters like pH, conductivity, turbidity, total dissolved oxygen, hardness, alkalinity, sulphate, phosphate, dissolved oxygen, BOD, COD, total coliform and faecal coliform were compared for 5 rivers (Simsang, Myntdu, Kyrhuhkhla, Ganol and Umtrew) three lakes (Wards lake, Umiam lake and Thadlaskein lake) and five springs (Mawpdang, Police Bazar, Umsahep, Wah-U-Dkahr and Narbong well) in Figs. 29 – 31 indicate the pollution level and quality of water in these bodies. The water quality in 1996 in the rivers and lakes also has been compared with that in 2002. Dissolved oxygen concentration in aquatic bodies though is much higher than the standard 3 mg/l, it shows a decline from 5.1-11 mg/l in 1996 to 5.8- 8.5 mg/l in 2002 (Table 23). The pH of water bodies in coal mine area has become acidic. There has been a decrease in pH of streams and rivers from 4.48 - 8.4 in 1996 to 3.1 - 7.5 in 2002 (Table 23). The profile of water quality (average of various water sampling sites) in Shillong city, analyzed during the years 1990-91, 1997, 1998, 1999 and 2000 is presented in table,

Impact

The colour of the water in most of the rivers and streams in the mining area has turned brownish or reddish orange due to presence of iron hydroxides [(Fe (OH)3]. Low pH (between 2-3), high conductivity, high concentration of sulphates, iron and toxic heavy metals, low dissolved oxygen (DO) and high BOD are some of the physico-chemical and biological parameters which characterize the degradation of water quality. The turbidity of water caused by suspended inorganic particles like clay, silt and sand and organic (bacteria, algae and plant debris) substances reduces light penetration and influence plant life. The rivers and streams during lean flow period are generally clear except those which flow in coal mining areas. As such the water is not good for health due to very low dissolved salt content and acidic nature, further degradation in the water quality take place due to abovementioned reasons posing threat to the human health. Pollution-related ailments such as cholera, typhoid, acute gastroenteritis, diarrhea, dysentery, poliomyelitis, viral hepatitis, skin diseases and others are common among citizens who use the river as a source of water. The rivers, streams and springs which supported rich biodiversity and were source of potable and irrigation water in the area have become unfit for growth of aquatic flora and fauna as well as for human consumption. The abundance and diversity of macro-invertebrates in the water bodies has declined, except a few tolerant species of benthic macro-invertebrates, and there is lack of commonly found aquatic organisms such as fish, frog and crustacean. There is an overall decline in agriculture productivity in coal mine area.

Responses

- Filling of mine pits, channeling of seepage water for checking contamination of water bodies and crop fields, afforestation with native species, undertaking effective soil conservation and water resources management programmes are some of the measures that can mitigate the problem and restore the degraded ecosystems of the area.
- A programme should be undertaken for regular monitoring of both surface and ground water for quality assessment and quality improvement.

❖

Coal mining is a major cause of ground water pollution

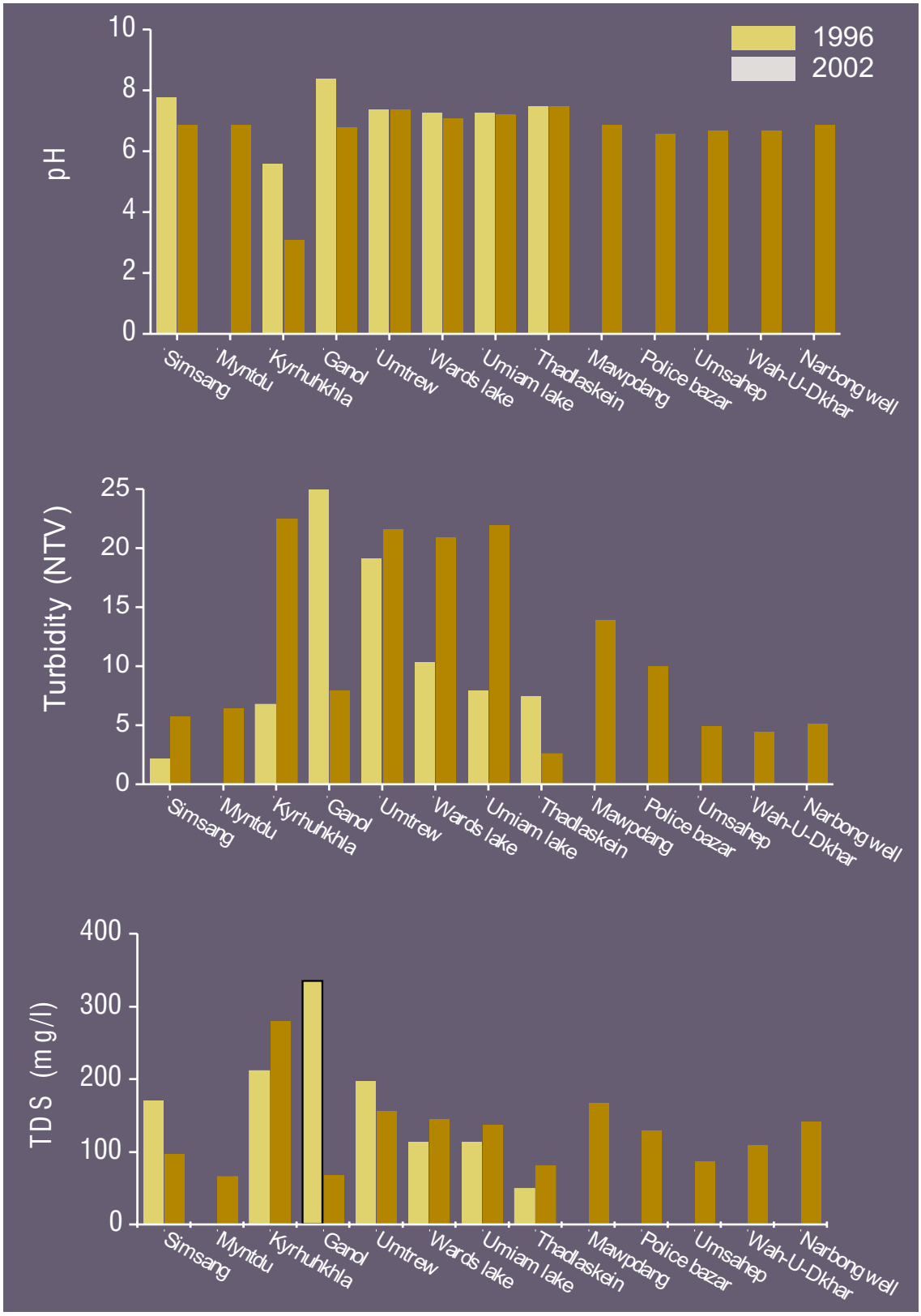


Fig. 29: Temporal variation in pH, turbidity and total dissolved solids of river and lake water of Meghalaya

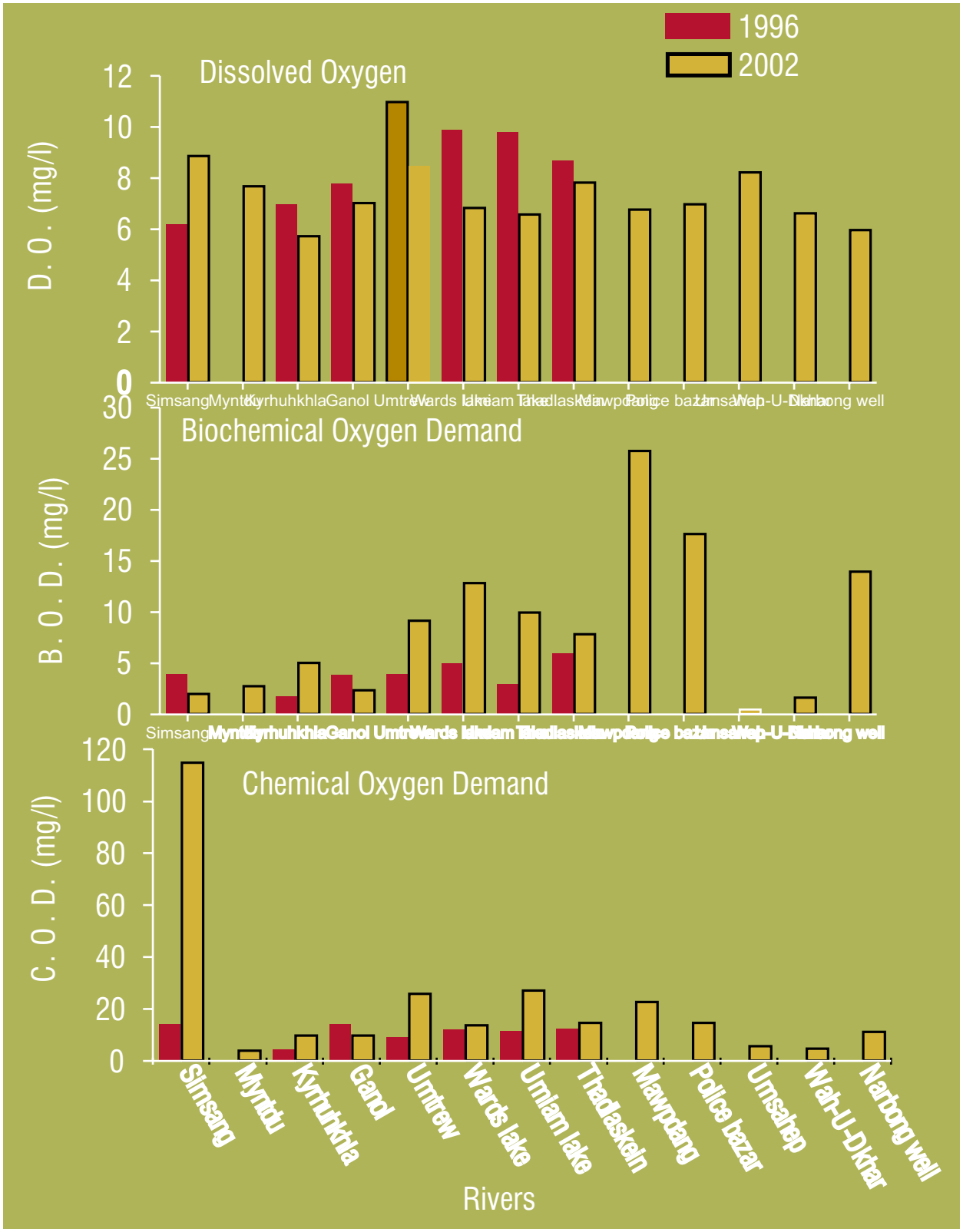


Fig. 30: Concentration of dissolved oxygen, biochemical and chemical oxygen demand in waters of different rivers, lakes and springs of Meghalaya

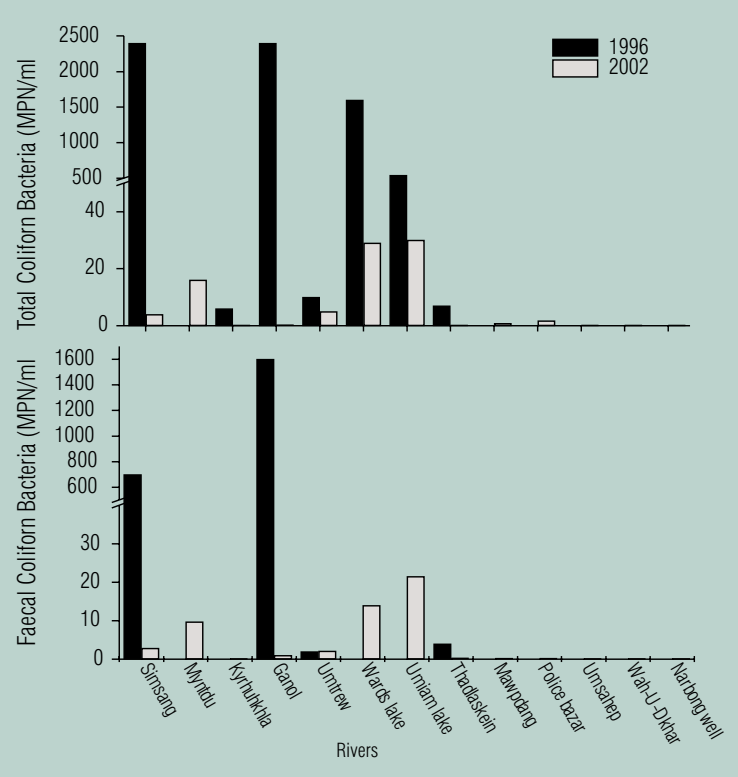


Fig. 31: Most probable number, of coliform bacteria in waters of different rivers, lakes and springs of Meghalaya

Table 23: Shillong water quality profile from 1990-91 to 2000

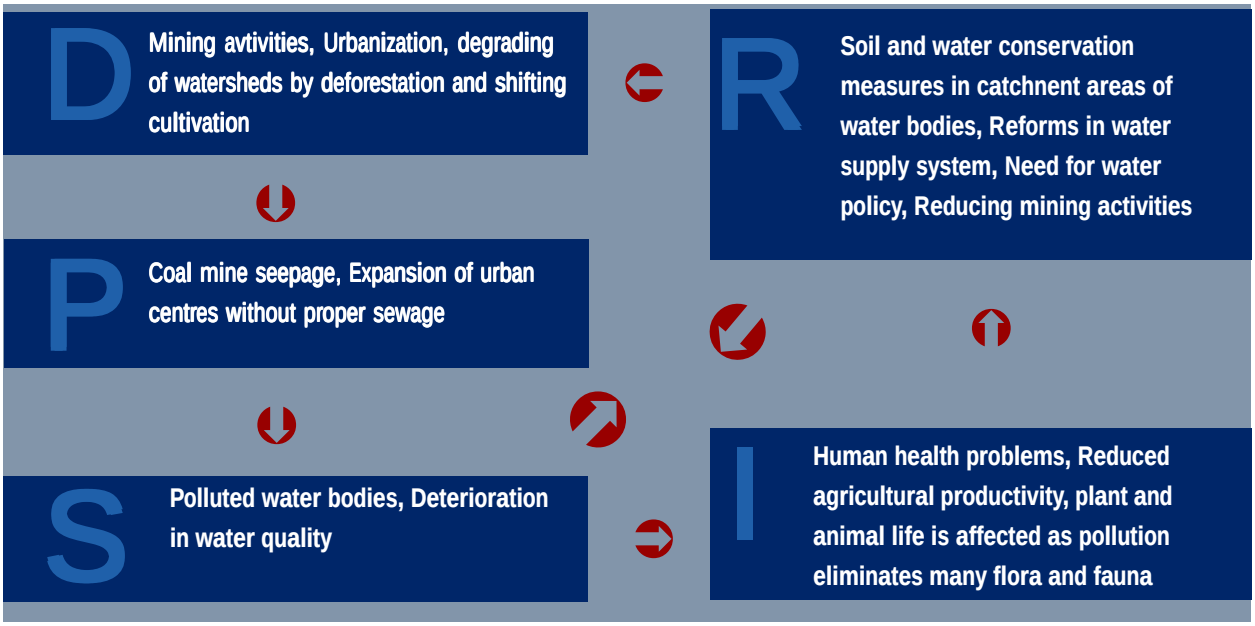
Parameters	Standard	1990-91			1997	1998	1999	2000		
		A	*B*	*C*	*Avg.*	*Avg.*	*Avg.*	*A*	*B*	C
pH	6.0 – 9.0	7.1	6.9	7	7	7.1	7.6	7	6.9	7.2
Conductivity (mho/cm)		14.3	105	183	290	285	360	125	188	221
Turbidity (NTU)		12.8	16	18	-	-	-	9.4	25	13.6
Nitrite-N (mg/l)		-	0.4	0.5	0.5	0.4	0.62	0.13	0.14	0.14
D. O. (mg/l)	3	9	5.3	3.7	3	2.5	-	9	7	7.9
BOD (mg/l)	6	0.3	30.5	45.7	94.5	96	112.5	67.2	104.2	43.2
COD (mg/l)		40	147.8	162	178.5	189	210	102	150	70.5
Oil & Grease (mg/l)	0.1	-	-	-	-	-	-	1.2	1.3	1
T. Coliform (MPN/100 ml)	5000	430	90,000	1,60,000	1,60,000	1,79,000	2,00,000	35,000	92,000	5,000
Faecal Coliform (MPN/100 ml)		-	2,600	35,000	1,10,000	1,15,000	1,30,000	24,000	90,000	50,000

Source: State Pollution Control Board, Shillong

Blue Issues

- Minimum flow should be ensured in the perennial streams for maintaining hydrological balance and meeting societal needs.
- Necessary legislation is to be enacted for preservation of existing water bodies by preventing encroachment and deterioration of water quality.
- Water use efficiency should be optimized and an awareness about water as a scarce resource should be fostered.
- Conservation consciousness should be promoted through education, regulation, incentives and disincentives.
- Need for a water policy for planning, development and management of water resources.
- Reforms in rural drinking water by adoption of a demand-driven, and community participation approach based on empowerment of villagers to plan, design, implement and manage water supply schemes,
- Water purification by using low cost simple technology
- Rain water harvesting and its storage

Figure 32: DPSIR analysis for water pollution



Part IV

Interstate Issues, Policies and Responses

Green Issues

There are several issues, which need to be resolved for effective control of deforestation, shifting cultivation and biodiversity loss. Some of these need to be addressed at the policy level and many of them need action-level remedial measures.

Inter-state Issues

The most important inter-state issue concerning green issues is the border dispute with the neighboring state of Assam and areas adjoining the international border with Bangladesh. The issues are:

- Encroachment of forest areas for settlement purpose by the villagers of the neighboring state/country thereby destroying forest and biodiversity.
- In order to earn their livelihood people practice shifting cultivation and over-exploit forest resources, causing serious damage to the forest and biodiversity.
- Inter-state disputed lands are often treated as no-man's land and therefore, there is no management activity on such lands.
- Illegal export of forest produces including timber across the international border.

Policies

State Government and National Government

The National Forest Policy 1988 is the guiding policy of the forest management in the state. The Forest (Conservation) Act, 1980, The Wildlife Protection Act, 1972 and JFM Guidelines, 1990, 2002 are some of the national legislations/policies that guide the management of state's forest. Other acts and rules impacting the extraction of forest produce in Meghalaya are:

- Meghalaya Forest Regulation, 1980 (Adapted from Assam Forest Regulation, 1890)
- The Garo Hills Regulation, 1882 (Regulation 1 of 1882)
- Meghalaya Forest Regulation (Application and Amendment) Act, 1973
- Meghalaya Forest (Removal of Timber) Regulation Act, 1981
- Meghalaya Tree Preservation Act, 1976
- Meghalaya Protection of Catchment Areas Act, 1988
- AWIL Fees Act, 1960
- The Bengal Cruelty to Animal Act, 1869
- The Meghalaya Wild Animal and Birds Protection Act, 1971 (Act 9 of 1971)
- The Cattle Trepass Act, 1871 (1 of 1871)

- The Elephant Preservation Act, 1879 (VI of 1879)
- Indian Fisheries Act 1897
- Livestock Importation Act, 1898
- Wild Birds and Animals Protection Act, 1912
- Prevention of Cruelty to Animals Act, 1960
- Prevention of Cruelty to Animals Rule 1960
- Prevention of Cruelty (capture of animals) Rules 1972
- The Wildlife (Transaction and Taxidermy) Rules, 1973
- The Wildlife (Stock Declaration) central Rules, 1973
- The Wildlife (Protection) Licensing (additional matters for consideration) Rules, 1983
- Transport of Animals Rules, 1978
- The Prevention of Cruelty to Animals (Registration of Cattle Premises) Rules, 1978
- Besides, Joint Forest Management Guidelines of 2003 and Guidelines for Forest Development Agencies, 2003 have also direct impact on the sharing of usufructs and benefits out of plantation forestry.

Although there is no formal forest policy adopted yet in the state (a draft policy paper was prepared in 1980 but not yet approved), the policy of the state forest department has been to increase the forest cover of the state by discouraging and regulating the felling in all categories of forests and greening barren areas which are under the constitutional jurisdiction of the District Councils. Attempts are also being made to streamline the administration of the forest and forestland under a single umbrella christened as 'unified control and management of the forests' of District Councils and the state forest department. Many rounds of discussions have taken place between the authorities of the District Council and the state government but there has been tangible result yet. Besides, it is also the intention of the department to create village reserve forests all over the state, in the same manner as the erstwhile village forests established by the people themselves during the pre-British period. The policy, *inter alia*, also lays stress upon the regulation of shifting cultivation, which is one of the major factors causing deforestation in the state.

The existing Assam Forest Regulation adopted by the state as the Meghalaya Forests Regulation is far from adequate to achieve the aims and objectives of the policy. Therefore, a few other acts have been legislated like the Meghalaya Removal of Timber Regulation Act, the Meghalaya Tree Preservation Act etc. The Meghalaya Tree Preservation Act was legislated with the prima facie objective of preventing the felling of trees within a radius of 10 km from the heart of Shillong. There is also an enabling provision to extend the same to the other district headquarters. However, the enforcement of the provisions of most of the Acts has been far from satisfactory.

Normally, as per provision of the Sixth schedule of the constitution of India, it is not possible for the State Government to interfere with the administration of forests in the Sixth scheduled areas. But through separate legislation, the State Government acts and rules can supercede the existing District Councils Acts also. Therefore, to discourage the felling of small trees in the District Council areas, the Acts attempt to regulate the marketing of the forest produce outside the state. This has been done based upon the logic that about 80 per cent of the timbers extracted from these forests go outside the state and the people of the state utilize hardly 20 per cent. Likewise, to conserve and preserve the forests in the critical catchment areas of the important rivers of the state, it is contemplated to legislate an Act, which will ban tree felling in these forests.

District Council Forest Acts

The District Councils have legislated separate forest acts and rules more or less in line with and in the same pattern as that of the State Forest Regulation. Three Autonomous District Council Forest Acts (viz., The United Khasi and Jaintia Hills Autonomous District (Management and Control of forest) Act, 1958, Jaintia Hills Autonomous District Council Forest Act and Garo Hills Autonomous District Council Forest Act, 1958 are applicable in their respective jurisdictions. According to the preamble of one of such acts (the United Khasi-Jaintia Hills Autonomous District (Management and control of forests) Act, 1958), "it is expedient to make laws relating to the management and control of forests in the areas of the Autonomous United Khasi Jaintia Hills District within the jurisdiction of the District Council as specified in the Sixth scheduled of the constitution of India". Unfortunately, this provision of the Acts could not be enforced and implemented in the true sense of the term. The Acts are self-contained with all the relevant desirable provisions, but the enforcement is not satisfactory. As a result of this, these forests have been subjected to indiscriminate felling during the last four decades.

Traditional Community Forest Laws

Most of the acts and laws passed by the Govt. of India, Govt. of Meghalaya and Autonomous District Councils remained less effective in managing the forests of the state. Contrary to this, the traditional institutions such as Syiemships, Doloiships, Sirdarships and Nokmaships have been forceful and effective till recently in managing the forests under their jurisdiction following customary laws. For instance, for Tangmang community forests, the following restrictions for forest management have been imposed under the customary law by the village durbar:

- No entry to the forests without permission from the durbar
- Tree felling allowed only for construction of community halls and other community works
- Fuelwood collection only by hand for bonafide domestic use
- Extraction of NTFPs is allowed only for personal consumption
- Hunting inside the community forest is not allowed
- Violators of the above restrictions and miscreants are fined.

Supreme Court Orders

In addition to the above policies, rules and acts, the supreme court orders (dated 12 December, 1996, 15 January, 1998 and 12 May, 2001) have direct or indirect relevance to the forests, shifting cultivation and biodiversity conservation in Meghalaya.

Responses

- Large-scale plantation programme both by state and national government through community participation on community areas by implementing effective schemes such as FDA.
- Externally funded projects for the management of upland agriculture including the livelihood issues and forest development, e.g. IFAD project
- Biodiversity conservation projects of NEC and Ministry of Environment and Forests, GOI
- JFM policies involving communities effectively
- Preparation of working schemes for community forests for initiating scientific management.
- People's innovations in shifting cultivation by introducing tree crops and switching to horticultural crops.

- Community initiatives for sustainable management and harvest of NTFPs.
- Initiative by communities, government and external agencies to regenerate the degraded sacred forests.
- Increase in awareness level among the people and officials
- Supreme court intervention

Brown Issues

Interstate/International Issues

Considering the long international border that Meghalaya shares with Bangladesh, both the issues, i.e. urbanization and coal mining are caused as well as affected by a host of international factors. For instance, the infiltration through international border does affect the demographic pattern in urban centres as well as in coal mining areas. On the other hand, the flourishing international coal market in Bangladesh has been the main reason for large-scale coal mining in Meghalaya. In order to control these problems, it is essential to have international cooperation and effective international policy mechanism.

Policies

The policies and acts those deal with the urbanization and coal mining are framed both by the state as well as national governments. However, the enforcement mechanism basically rests with the state government. For instance, the environmental aspect of mining is regulated through the Environmental Protection Act, 1986 (EPA), Environmental Policy, 2000 and Environmental Impact Assessment Notification, 1994 formulated/enacted by the Government of India. Although the clearing of the projects rests with the Govt. of India, most of the enforcement part is looked after the state Pollution Control Board. As such, the EPA has not so far been applicable to private miners in Meghalaya as the land and resources on it belong to the tribals and are protected under the sixth schedule of Indian Constitution.

Blue Issues

Interstate/International Issues

Most rivers of Meghalaya drain into the territory of Banglades. The Indo-Bangladesh Water Treaty regulates the water usage in these rivers. There has been no conflict between India and Bangladesh in the context of sharing of water originatiing or passing through Meghalaya. There has also been no conflict over water resources between Assam and Meghalaya

Policies

The following national policies and acts are either adopted or directly implemnted in the state to regulate water pollution.

- Draft Environment Policy, 2004
- Water Act, 1971
- Environmental Protection Act, 1986
- Environmental Impact Assessment Notification, 1994

All the above Policies/Regulations/Acts are enforced by the Government of India. At thestate level, no policy has been adopted for the management of water resources.

Part V
Challenges Ahead

Green Issues

Deforestation

As already mentioned, the community forests in Meghalaya are owned by clans, village durbars, syiems, Sirdars, Dolois and Nokmas. Although such forests are supposed to be managed according to the provisions of the respective District Council Forests Act, in practice, hardly there exists any management system. District Councils virtually have no control over these forests and no scientific management system is followed. Although Selection felling is practised in certain community forests, most of these forests are harvested when the need arises and are quite often overexploited under the influence of some dominant/influential community members. Weakening of traditional and customary laws, gradual conversion of community lands into private lands, and diminishing influence of the traditional institutions over the society have resulted into either very little control or no control regime for the community forests. All these have contributed to unregulated tree felling in these forests. In addition, because of the low productivity (in absence of scientific forestry) and long gestation period, many of these community forests are being converted to cash crop plantation areas such as Broom grass (*Thysanolaena maxima*), Rubber (*Havea brasilensis*) and Arecanut (*Areca catechu*). Substantial areas of community forests are also being diverted for growing horticultural crops such as pineapple, ginger, orange orchards (*Citrus* spp.) and often Lichi (*Litchi chinensis*) and Bayleaf (*Cinamomum tamala*) mixed with forestry tree species. All these activities though commercially beneficial, have a direct impact on the biodiversity and ecosystem functioning at a landscape level. Besides, these activities mostly benefit a few land/forest owning community at the cost of the poor majority whose livelihood options are severely affected due to vanishing of multi-species community forests.

Even the sacred forests, also one type of community forests, are fast vanishing. A study conducted by Tiwari et al in 1999 reveals that barring only 1% of the total sacred forest area of the state, all other sacred forest areas are moderate to highly degraded.

It is often argued that the indigenous forest management systems are time-tested and are adequate for the sustainability of the community/private owned forests. As a testimony to this statement, there do exist certain patches of well-conserved/preserved community forests throughout Meghalaya. This has been primarily possible because of strong regulatory mechanism that is still in force at village durbar level. However, the number of such patches is depleting year after year indicating the inadequacy of self-governed traditional institutions to sustain the community forests. This is also apparent from the overall scenario of the condition of forests in the state, which have become considerably degraded both quantitatively and qualitatively over the years. In the absence of long-term data on forest cover and forest health (growing stock), empirically, it may not be possible to prove this point. However, when discussed with elderly persons having exposure to the forestry issues or if asked to a common man, and from our own field experience over the years, the above conclusion is found to be correct. Although the FSI data over a decade shows more or less constant forest cover in the state, it does not indicate the dynamics of growing stock thereby remaining silent on the conditions of forest health. The decline in dense forest cover over the years, as reported by FSI, although does prove this point.

The communities in general, the land owning clans/communities, private forest owners and the management systems in place for the management of these forests are to be blamed for such a decline in quantity and quality of the forests of the state, as the government do not have any interference in the management of community forests. In fact, in Meghalaya, before the intervention of the Supreme

Court, there was absolutely no regulatory and controlling power of the state in relation to the land ownership, use and disposal of forest produce pertaining to the forests which are in the hands of communities and private individuals. Therefore, it is amply clear that there is some inadequacy in the regulatory mechanism of the traditional management systems resulting in the large-scale degradation of forests in the state. It could be due to growing need of the land/forest owning communities, operating market forces, seer human greed and aspiration for adopting a modern life style, leading to the degradation of the forests. Even wherever the traditional forest management system is still strong, the forests have not been able to withstand the pressure arising from these factors because of inherent weaknesses in the traditional systems which are based mostly on the principle of 'preservation' and 'low production forestry'.

All these facts bring home one point, and that is. there is a need to strengthen the traditional forest management mechanism through peripheral intervention. The Supreme Court verdict in this context is a welcome measure. In fact, in its series of verdicts/judgements, the Supreme Court has tried to regulate the indiscriminate tree felling and attempted to introduce scientific management in the community forests through introducing the concept of working schemes for achieving sustained yield. Thus, the Supreme Court verdict should not be seen as a setback to the 'greater autonomy of the forest management by the institutions of self-governance' (Nongbri 2001). Of course, a lot still needs to be done to implement and operationalize the verdict in its right spirit. For instance, the myths about the Supreme Court rulings such as (i) complete ban of tree felling from the forest, and (ii) that the Supreme Court is facilitating the increased state control over the community forests etc. need to be clarified in the minds of the people. Besides, preparation of working schemes for such a huge forest track is not an easy task to be accomplished within given time framework. The forest department at present does not have that huge man power to accomplish the task neither the village communities have the capacity to undertake such task. Therefore, there is a need to work out a well-planned policy outlining the strategies to be adopted for achieving the broader objective of sustainable forest management in community/private owned forest areas.

Policy Needs

- **Identifying areas and extent of government intervention for developing an effective forest policy**

  In order to effect sustainable forest management practices in the community forests, specific areas of intervention and the extent of intervention are required to be identified very carefully. A people-friendly policy needs to be developed by the government that would ensure a favourable environment for government and community participation in conserving the community and private forests. The areas where facilitation is required, and the areas where regulatory mechanisms are to be there, strategies for strengthening the traditional institutions for effective forest management need to be identified for formulating an effective and implementable community forest policy of Meghalaya. While identifying such areas of intervention, sensitivity regarding government interference in community affairs and autonomy of traditional institutions should be kept in mind. The fear of land alienation due to government interference in people's mind and the issue of possible alteration of land ownership must be given top priority while undertaking such an exercise for developing the appropriate policy.

- **Removing the irritations in the existing rules and acts**

  Research needs to be taken up to identify the bottlenecks and deterrents that retard the spirit of forest conservation among the communities. In order to create a favorable environment for communities to work towards sustainable forestry, all the existing acts, rules and regulations need to be critically reviewed and points for amendment need to be identified in close consultation with the communities

- **Capacity building**

  Considering the need of practicing scientific forestry in community and private forests, which is viewed to be a viable strategy to ensure the continued existence of forests on community and private land, and given the limitations of the state forest departments in terms of number of forestry personnel vis-à-vis the large forest areas under community/private ownership, it is desirable to train the representatives of village durbars on various aspects of technical forestry. Researches need to be under taken for identifying the areas and topics for capacity building program for the communities. The modus operandi to commence such programs also need to be worked out.

Shifting Cultivation

- **Controlling the population growth**

  Land area available for cultivation has to be increased due to increase in population. Thus, area under shifting cultivation increases at the cost of undisturbed forest area.

- **Developing alternatives to shifting cultivation**

  In the absence of any viable alternative to shifting cultivation, it is not possible to control shifting cultivation. Till date no such alternatives have been worked out. Thus, efforts should be made to find out a viable solution to this vexed problem.

- **Alternate livelihood strategies**

  Alternate sources of income such as development of handicrafts through cottage industries, local value addition of forest and agricultural products, popularization of new land-based activities such as fisheries, horticulture, apiculture, mushroom farming and sustainable NTFP production from forest areas need to be encouraged. Effective market-linkage must be ensured to sustain such activities. Grassroots level organizations such as Self-Help Groups have been effective in working out alternative livelihood strategies and thus, reducing the area of shifting cultivation.

- **Monitoring the areas under shifting cultivation**

  Up to date empirical data on acres under shifting cultivation is not available. There is a need to map the shifting cultivation area of the state and their status need to be assessed periodically using satellite imaging. This could help players to effectively tackle the problem of shifting cultivation.

Biodiversity loss

- Policies for protecting the existing biodiversity-rich areas both at community and government levels should be formulated. Extension of the prioroties of the Wildlife Protection Act, 1972 to community is a welcome step in this direction.
- Adequate funding for conservation of such biodiversity-rich areas should be ensured after inventorization and demarcation of these areas.
- Capacity building program for the communities should be undertaken to assess, document, monitor and manage the biodiversity at local level.
- More areas irrespective of ownership need to be brought under PA network
- Research support for conservation of fragile ecosystems and threatened category of species should be provided.
- Regeneration efforts for the degraded areas and restoration of biodiversity-rich landscapes need to be initiated.
- Studies on key stone species and their conservation need to be undertaken.

Brown Issues

Urbanization

- Controlling population growth both in urban and rural Meghalaya.
- Checking rural – urban migration by providing better livelihood options and quality of life, and creating new employment opportunities in rural areas.
- Reducing overcrowding of urban areas through appropriate policies.
- Maintaining urban environment through appropriate technologies.

- Adopting measures to recycle the wastes.
- Checking the vehicular growth, and sources of water and air pollution, in urban areas.

Mining

- To regulate mining or to introduce environmental safeguards, particularly in unorganized sector is a major challenge, as government does not have control over the land and its resources in sixth scheduled areas, which belong to the local people. A landscape level approach for the planning of mines needs to be undertaken.
- The adoption of scientific mining and compliance to a well designed environmental management plan under the EIA notification should be able to check the environmental problems relating to mining to a great extent. However, the challenge is, neither EPA, 1986 nor the EIA notification, 1994 are applicable to all these areas.
- Diversion of forestlands to non-forest uses, particularly mining should be totally stopped. In other words, FC Act, 1980 should be extended to all these areas.
- The owners of the mines should be educated about the environmental consequences of unscientific mining . A well-thought out and planned awareness programme should be undertaken for all the stakeholders. For this, a nodal agency needs to be identified and adequate resources should be provided for such programmes.
- There is a dearth of appropriate technology for rehabilitation of mine-affected areas, which are essentially site-specific. Therefore, a comprehensive programme of technology development for ecorestoration of these areas needs to be taken up. Besides, the existing technologies should be applied immediately for the rehabilitation of mined areas. The required funding for such programmes should be made available by the Ministry of Environment and Forests, Govt. of India.
- Social issues and human health problems in mining areas need to be addressed.

Blue Issues

Water Pollution

- The discharge of domestic, industrial and hospital sewage directly to the streams and rivers is the main reason of water pollution in the state. In mine-affected areas, discharge from the mines and over burdens are the source of pollution. Appropriate and effective measures need to be taken to check pollution load.
- Non-point source of water pollution such as sediment loss, nutrient leaching from the catchment areas are increasing silt load and eutrophication of waterbodies. Therefore, massive programmes of afforestation in catcment areas of major rivers and lakes need to be taken up.
- Strict enforcement of Acts and Regulations relating to control of water pollution and mining needs to be done.
- The quality of portable water should be monitored and maintained.

Water Scarcity

- Although the water scarcity in dry months is acute in Meghalaya, precise empirical data in this regard is not available. A comprehensive study to quantify the water scarcity needs to be commissioned urgently.
- A water management plan should be prepared and implemented for the conservation and optimum use of water resources.
- A water use policy needs to be adopted and the practice of ‘user pay’ concept should be introduced.
- Considering the effectiveness of the traditional institutions in Meghalaya, participatory approach to water and watershed management should be encouraged.
- Innovative and appropriate technologies for water conservation and harvesting should be employed.

- Awareness raising programme for the users should be taken up.
- Underutilized water sources such as ground water should be taped. Various rain water harvesting technologies including roof-top harvesting and check dams along the streams may be popularized.
- The existing water supply system should be upgraded for better water conservation and management.

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Annexure I

Statistical Profile of the State	
Geographic Area	22429 Sq. km.
Capital	Shillong
No. of Districts	7
Tribes	Khasi, Jaintia and Garo
Languages	Khasi, Jaintia, Garo, English, Hindi
Population (Census of India, 2001)	23,06,069
Males	1,167,840
Females	1,138,229
Decadal Growth Rate (%)	29.94
Density (person per sq km.)	103
Rural Population	18,53,457
Urban Population	4,52,612
Sex ratio (females per thousand males)	975
Literacy (%)	63.31
Males	66.14
Females	60.41

Annexure II

Number of literates and literacy percentage by sex in different districts of Meghalaya

State/Districts	Literates			Literacy Rate (%)					
				1991			2001		
	Persons	Males	Females	Persons	Males	Females	Persons	Males	Females
Meghalaya	1,789,717	1,170,443	551,489	49.10	53.12	44.85	63.31	66.14	60.41
West Garo Hills	213,970	120,871	93,099	38.64	46.10	30.81	51.03	57.51	44.51
East Garo Hills	122,350	68,278	54,072	48.38	54.70	41.70	61.70	67.39	55.74
South Garo Hills	43,659	25,241	18,418	42.88	51.28	34.02	55.82	62.60	48.61
West Khasi Hills	148,868	77,179	71,689	50.52	52.98	47.94	65.64	67.02	64.21
Ri Bhoi	97,473	52,989	44,484	39.93	43.88	35.73	66.07	69.22	62.67
East Khasi Hills	422,329	215,937	206,392	64.58	67.13	61.86	76.98	78.12	75.82
Jaintia Hills	121,794	58,779	63,015	35.32	34.37	36.31	53.00	50.52	55.54

[Source: Census of India-2001]

Annexure III

Area, populations, numbers of townships and headquarters of districts of Meghalaya

			Area (Sq.km.)	Head Quarters	No. of inhabited Villages	Towns
State		Meghalaya	22429	7	5484	16
1:	District	East Khasi Hills	2748	Shillong	899	Shillong
	Blocks	Mawphlang	290			
		Mylliem	204			
		Mawryngkneng	293			
		Mawkynrew	355			
		Mawsynram	523			
		Shella Bholaganj	578			
		Pynursla	505			
2:	District	West Khasi Hills	5247	Nongstoin	914	Nongstoin
	Blocks	Mawshynrut	1614			
		Nongstoin	974			
		Mairang	1106			
		Ranikor	695			
		Mawkyrwat	858			
3:	District	Jaintia Hills	3819	Jowai	465	Jowai
	Blocks	Thadlaskein	753			
		Laskein	553			
		Amlarem	398			
		Khliehriat	2115			
4:	District	Ri-Bhoi	2448	Nongpoh	570	Nongpoh
	Blocks	Umling	1216			
		Umsning	1232			
5:	District	East Garo Hills	2603	William Nagar	856	William Nagar
	Blocks	Resubelpara	468			
		Dambo Rongjeng	885			
		Songsak	703			
		Samanda	547			
6:	District	West Garo Hills	3677	Tura	1481	Tura
	Blocks	Betasing	301			
		Dalu	622			
		Selsella	535			
		Dadenggri	617			
		Tikrikilla	330			
		Rongram	867			
		Zikzak	405			
7:	District	South Garo Hills	1887	Baghmara	595	Baghmara
	Blocks	Chokpot	649			
		Baghmara	651			
		Rongara	587			

Source: Directorate of Economics & Statistics-2002

Annexure IV

Administrative units of Meghalaya (As of 2002)

Units	Jaintia Hills	East Khasi Hills	Ri Bhoi District	West Khasi Hills	East Garo Hills	West Garo Hills	South Garo Hills	Meghalaya
Sub-Divisions (other than district headquarters)	2	1	-	2	1	2	-	8
Police Stations	3	10	2	3	3	4	1	26
Police Outpost	5	4	6	3	5	7	2	32
Community Development Blocks	5	8	3	6	5	8	4	39
Towns	1	8	1	2	2	1	1	16
No. of Villages	465	899	570	914	856	1481	595	5780

Source: Directorate of Economics & Statistics-2002

Annexure V

Endemic (E), rare (R) and threatened (T) plant species found in sacred groves of Jaintia hills, Meghalaya

Plant species	Status	Distribution
Acer laevigatum Wall.	E, R	Temperate Himalaya, Sikkim and Meghalaya
Acer oblongum Wall.	R	Indo-Malaya, Himalayas and North East India
*Aeschynanthes parasiticus (Roxb.) Wall.	E	Endemic to Meghalaya
Aeschynanthes sikkimensis (Clarke) Stapf.	E, R	Sikkim, North East India
**Aeschynanthes superba* Clarke.	E	Endemic to Meghalaya
Aralia thomsonii Seem	E	Eastern Himalayas
Ardisia disperma Cl.	R	Eastern Himalaya to Burma
**Ardisia griffithii* Cl.	E	Endemic to Meghalaya
Ardisia odontophylla DC.	R	Burma & North East India
Balanophora dioca Royle	R	Sub-Himalayas, North East India, Indo-Burma and Nepal
**Baliospermum micranthum* Muell-Arg.	E	Endemic to Meghalaya
Boehmeria sidaefolia Wedd.	E	Indo-Malaya
Bruceae mollis Wall. ex Kurz.	R	South-East Asia, North East India & Andamans
Bulbophyllum griffithii (Lindl.) Reiclb	E, R	Sikkim & North East India
Callicarpa psilocalyx Clarke	E, R	North East India
**Camellia caduca* Cl. ex Brandis	E	Endemic to Meghalaya
Carpinus viminea Lindl.	E	Temperate Himalaya & Burma
Capparis acutifolia Sweet	E	Endemic to North East India
Ceropegia angustifolia Wt.	E, R	North East India
Cinnamomum pauciflorum Nees	E, R	North East India
**Citrus latipes* (Swingle) Tanaka	E, R	Endemic to Meghalaya
Croton oblongus Burm.f.	R	Indo-Malaya
Cyathea gigantea (Wall ex Hook.) Holttm	R, T	North East India
Dendrobium densiflorum Wall.	R	Sikkim, North East India, Indo-Nepal
Dendrobium devonianum Paxt.	R	North East India, Sikkim, Bhutan, Burma & Thailand
Dendrobium nobile Lindl.	R	North East India, Sikkim, Bhutan, Nepal, Thailand & China
Dipteris wallichii (R.Br.) Moore	R	North East India
Drimycarpus racemosus (Roxb.) Hook.f.	E	Eastern Himalayas & Bangladesh
Drosera peltata Smith	R	Himalayas, Indo-Malaya, Nilgiris & Australia
Embelia vestita Roxb.	R	North East India
Erythroxylum kunthianum Wall. ex Kurz	E	Indo-Burma, North East India

Plant species	Status	Distribution
**Euonymus lawsonii* Clarke & Prain	E	Endemic to Meghalaya
Ficus concinna Miq.	R	North East India
Ficus subincisa Buch.-Ham. ex J.E.SH	R	Himalaya to Burma
Fissistigma verrucosum (Hk.f.&Th) Merr.	E, R	Endemic to North East India
Fraxinus floribunda Wall.	R	Temperate & Sub-Himalaya
Glochidion thomsonii (Muell-Arg.) Hook. f.	E	Bangladesh, North-East India
Gnetum montanum Mark Graf	R	Eastern Himalayas, North East India, South India, Indo-China
**Gomphostemna lucidum* Benth.	E, R	Endemic to Meghalaya
**Goldfussia glabrata* (Nees) Balakr.	E	Endemic to Meghalaya
Hedera nepalensis K.Koch	E, R	Bhutan Himalayas
**Ilex embeloides* Hook.f.	E, R	Endemic to Meghalaya
**Ilex venulosa* Hook.f.	E, R	Endemic to Meghalaya
**Impatiens acuminata* Hook.f.	E	Endemic to Meghalaya
**Impatiens juripa* Hook. f. & Th	E	North-East India
**Impatiens khasiana* Hook.f. & Th	E	Endemic to Meghalaya
**Impatiens laevigatum* Hook.f. & Th	E	Endemic to Meghalaya
**Impatiens porrecta* Hook. f. & Th	E	Endemic to Meghalaya
Ixora subsessiles G.Don	E	North-East India
Leucosceptrum canum Smith	R	Temperate & Sub-Himalayas
**Lindera latifolia* Hook.f.	E, R	Endemic to Meghalaya
Litsea leata (Nees) Hook.f.	E	Bangaladesh & Eastern Himalayas
Luisia inconspicua (Hook.f) King & Pantl.	E, R	Sikkim, North East India
Mahonia pycnophylla (Fedde) Takeda	E	Indo-Burma, Eastern Himalayas & Nilgiris
Manglietia insignis Bl.	R	Eastern Himalayas
Melodinus monogynous Roxb.	R	Indo-Malaya, North-East India
Morinda umbellate Linn.	R	Burma, Bangladesh, Himalaya & Sub-Himalaya
Munronia pinnata (Wall.) Harms.	R	Tropical Himalaya & Nilgiris
Neillia thyrsiflora D.Don	E	Indo-Malaya and Himalayas
Osbekia capitata Benth.	E	East Bhutan, Meghalaya
**Paramignya micrantha* Kurz	E	Endemic to Meghalaya
**Persea parviflora* (Meissn).Haridasan et Rao	E	Endemic to Meghalaya
Phlogancanthus pubinervius T. Andes	E	Eastern Himalayas

Plant species	Status	Distribution
Piper griffithii C.DC.	E	North East India
Piper peepuloides Roxb.	E	Himalayas, North East India
Pleione maculata (Lindl.) Lindl.	R	North East India, Sikkim, Bhutan, Nepal & Thailand
Pleione praecox (Lindl.) Lindl.	R	North East India, Sikkim, Bhutan, Nepal, Burma & Thailand
Podocarpus neriifolia D.Don	R	North East India, Indo-Burma, Malaya & Japan
Pseudobrassiopsis hispida (Seem.) R.N.Ban	R	Burma & North East India
Pyrularia edulis A. DC.	R	Temperate & Subtropical Himalayas
**Pogostemon strigosus* (Benth.) Benth.	E	Endemic to Meghalaya
Porana racemosa Roxb.	E, R	Subtropical Himalayas to Burma
Prunus jenkinsii Hook.f.	E	North East India
Psychotria symplicifolia Kurz.	E, R	Burma, North East India
Quercus glauca Thunb.	R	Subtropical Himalayas & Japan
Rapidophora calophyllum Schott.	E	Endemic to North East India
Rapidophora decursiva (Roxb.) Schott.	E	Sikkim & North East India
Rhus hookerii Sahni & Bahd.	R	Sikkim Himalayas and Meghalaya
Rubus assemensis Focke	E	Burma, North East India
**Rubus khasianus* Cordat	E	Endemic to Meghalaya
Sarcosperma griffithii Cl.	R	North East India
**Schima khasiana* Dyer.	E, R	Endemic to Meghalaya
**Senecio jowaiensis* Balakr.	E	Endemic to Meghalaya
Smilax myrtillus DC.	E	North east India
**Sonerila khasiana* Cl.	E, R	Endemic to Meghalaya
Styrax hookerii Cl.	R	Eastern & Sub-Himalayas
**Sympagia monodelpha* (Nees) Bremek.	E	Endemic to Meghalaya
**Tupidanthus calyptratus* Hk.f. & Th.	E, R	Endemic to Meghalaya
Turpina nepalensis W. & A. Prodr.	E, R	Indo-Malaya
Vaccinium vacciniaceum (Roxb.) Sleum.	E	North East India
**Viburnum simonsii* Hk.f. & Th.	E	Endemic to Meghalaya

Annexure VI

Endemic (E), rare (R) and threatened (T) plant species found in sacred groves of Jaintia hills.

Plant species	Status	Distribution
Acer laevigatum Wall.	E, R	Temperate Himalaya, Sikkim and Meghalaya
Acer oblongum Wall.	R	Indo-Malaya, Himalayas and North East India
**Aeschynanthes parasiticus* (Roxb.) Wall.	E	Endemic to Meghalaya
Aeschynanthes sikkimensis (Clarke) Stapf.	E, R	Sikkim, North East India
**Aeschynanthes superba* Clarke.	E	Endemic to Meghalaya
Aralia thomsonii Seem	E	Eastern Himalayas
Ardisia disperma Cl.	R	Eastern Himalaya to Burma
**Ardisia griffithii* Cl.	E	Endemic to Meghalaya
Ardisia odontophylla DC.	R	Burma & North East India
Balanophora dioca Royle	R	Sub-Himalayas, North East India, Indo-Burma and Nepal
**Baliospermum micranthum* Muell-Arg.	E	Endemic to Meghalaya
Boehmeria sidaefolia Wedd.	E	Indo-Malaya
Bruceae mollis Wall. ex Kurz.	R	South-East Asia, North East India & Andamans
Bulbophyllum griffithii (Lindl.) Reiclb	E, R	Sikkim & North East India
Callicarpa psilocalyx Clarke	E, R	North East India
**Camellia caduca* Cl. ex Brandis	E	Endemic to Meghalaya
Carpinus viminea Lindl.	E	Temperate Himalaya & Burma
Capparis acutifolia Sweet	E	Endemic to North East India
Ceropegia angustifolia Wt.	E, R	North East India
Cinnamomum pauciflorum Nees	E, R	North East India
**Citrus latipes* (Swingle) Tanaka	E, R	Endemic to Meghalaya
Croton oblongus Burm.f.	R	Indo-Malaya
Cyathea gigantea (Wall ex Hook.) Holttm	R, T	North East India
Dendrobium densiflorum Wall.	R	Sikkim, North East India, Indo-Nepal
Dendrobium devonianum Paxt.	R	North East India, Sikkim, Bhutan, Burma & Thailand
Dendrobium nobile Lindl.	R	North East India, Sikkim, Bhutan, Nepal, Thailand & China
Dipteris wallichii (R.Br.) Moore	R	North East India
Drimycarpus racemosus (Roxb.) Hook.f.	E	Eastern Himalayas & Bangladesh
Drosera peltata Smith	R	Himalayas, Indo-Malaya, Nilgiris & Australia
Embelia vestita Roxb.	R	North East India
Erythroxylum kunthianum Wall. ex Kurz	E	Indo-Burma, North East India

Plant species	Status	Distribution
**Euonymus lawsonii* Clarke & Prain	E	Endemic to Meghalaya
Ficus concinna Miq.	R	North East India
Ficus subincisa Buch.-Ham. ex J.E.SH	R	Himalaya to Burma
Fissistigma verrucosum (Hk.f.&Th) Merr.	E, R	Endemic to North East India
Fraxinus floribunda Wall.	R	Temperate & Sub-Himalaya
Glochidion thomsonii (Muell-Arg.) Hook. f.	E	Bangladesh, North-East India
Gnetum montanum Mark Graf	R	Eastern Himalayas, North East India, South India, Indo-China
**Gomphostemna lucidum* Benth.	E, R	Endemic to Meghalaya
**Goldfussia glabrata (Nees)* Balakr.	E	Endemic to Meghalaya
Hedera nepalensis K.Koch	E, R	Bhutan Himalayas
**Ilex embeloides* Hook.f.	E, R	Endemic to Meghalaya
**Ilex venulosa* Hook.f.	E, R	Endemic to Meghalaya
**Impatiens acuminata* Hook.f.	E	Endemic to Meghalaya
**Impatiens juripa* Hook. f. & Th	E	North-East India
**Impatiens khasiana* Hook.f. & Th	E	Endemic to Meghalaya
**Impatiens laevigatum* Hook.f. & Th	E	Endemic to Meghalaya
**Impatiens porrecta* Hook. f. & Th	E	Endemic to Meghalaya
Ixora subsessiles G.Don	E	North-East India
Leucosceptrum canum Smith	R	Temperate & Sub-Himalayas
**Lindera latifolia* Hook.f.	E, R	Endemic to Meghalaya
Litsea leata (Nees) Hook.f.	E	Bangaladesh & Eastern Himalayas
Luisia inconspicua (Hook.f) King & Pantl.	E, R	Sikkim, North East India
Mahonia pycnophylla (Fedde) Takeda	E	Indo-Burma, Eastern Himalayas & Nilgiris
Manglietia insignis Bl.	R	Eastern Himalayas
Melodinus monogynous Roxb.	R	Indo-Malaya, North-East India
Morinda umbellate Linn.	R	Burma, Bangladesh, Himalaya & Sub-Himalaya
Munronia pinnata (Wall.) Harms.	R	Tropical Himalaya & Nilgiris
Neillia thyrsiflora D.Don	E	Indo-Malaya and Himalayas
Osbekia capitata Benth.	E	East Bhutan, Meghalaya
**Paramignya micrantha* Kurz	E	Endemic to Meghalaya
**Persea parviflora* (Meissn).Haridasan et Rao	E	Endemic to Meghalaya
Phlogancanthus pubinervius T. Andes	E	Eastern Himalayas

Plant species	Status	Distribution
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Podocarpus neriifolia D.Don	R	North East India, Indo-Burma, Malaya & Japan
Pseudobrassiopsis hispida (Seem.) R.N.Ban	R	Burma & North East India
Pyrularia edulis A. DC.	R	Temperate & Subtropical Himalayas
**Pogostemon strigosus* (Benth.) Benth.	E	Endemic to Meghalaya
Porana racemosa Roxb.	E, R	Subtropical Himalayas to Burma
Prunus jenkinsii Hook.f.	E	North East India
Psychotria symplicifolia Kurz.	E, R	Burma, North East India
Quercus glauca Thunb.	R	Subtropical Himalayas & Japan
Rapidophora calophyllum Schott.	E	Endemic to North East India
Rapidophora decursiva (Roxb.) Schott.	E	Sikkim & North East India
Rhus hookerii Sahni & Bahd.	R	Sikkim Himalayas and Meghalaya
Rubus assemensis Focke	E	Burma, North East India
**Rubus khasianus* Cordat	E	Endemic to Meghalaya
Sarcosperma griffithii Cl.	R	North East India
**Schima khasiana* Dyer.	E, R	Endemic to Meghalaya
**Senecio jowaiensis* Balakr.	E	Endemic to Meghalaya
Smilax myrtillus DC.	E	North east India
**Sonerila khasiana* Cl.	E, R	Endemic to Meghalaya
Styrax hookerii Cl.	R	Eastern & Sub-Himalayas
**Sympagia monodelpha* (Nees) Bremek.	E	Endemic to Meghalaya
**Tupidanthus calyptratus* Hk.f. & Th.	E, R	Endemic to Meghalaya
Turpina nepalensis W. & A. Prodr.	E, R	Indo-Malaya
Vaccinium vacciniaceum (Roxb.) Sleum.	E	North East India
**Viburnum simonsii* Hk.f. & Th.	E	Endemic to Meghalaya

*Endemic to Meghalaya, # 1 = Khloo Blai, 2 = Khloo Poh Lyngdoh, 3 = Khloo Paiu Ram Pyrthai, 4 = Urkhla and 5 = Khloo Langdoh sacred grove0s