State of the Environment

Sri Lanka

2001

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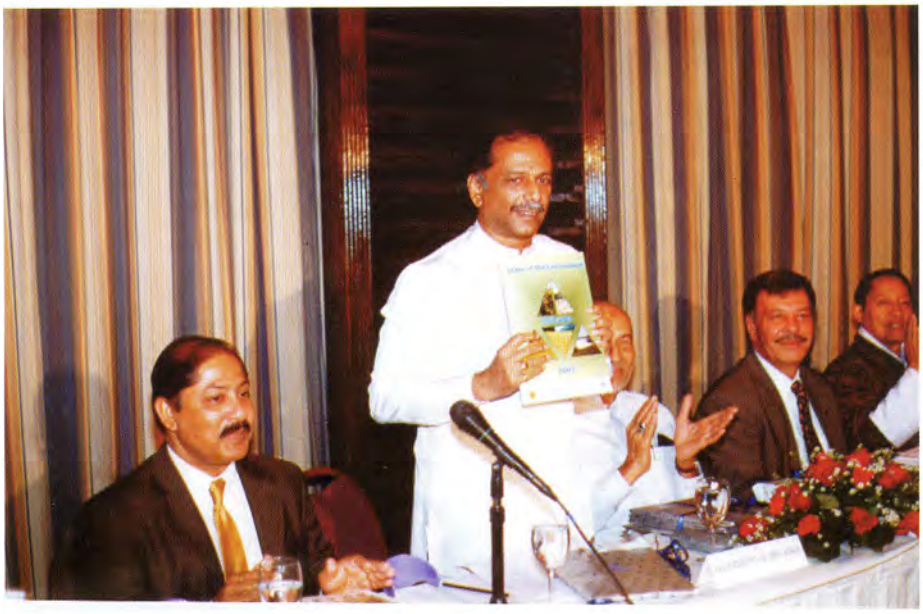
NORAD
DIREKTORATET FOR UTVIKLINGSHJELP
NORWEGIAN AGENCY FOR DEVELOPMENT COOPERATION

UNEP

Hon. Minister Dinesh Gunawardena launched the Sri Lanka : State of the Environment 2001 on 29 September 2001 at the Hilton Colombo,Sri Lanka. The Ministry of Forestry and Environment is now renamed as the Ministry of Transport and Environment.



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Published by the United Nations Environment Programme

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ISBN: 92-807-2016-3

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Cover designed by Purna Chandra Lall Rajbhandari and Ric Dennis A. Canullas
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Distributed by

United Nations Environment Programme
Regional Resource Centre for Asia and the Pacific
(UNEP-RRC.AP)
Outreach Building, Asian Institute of Technology
P.O. Box 4, Klong Luang, Pathumthani 12120
Thailand

FOREWORD

The Rio Earth Summit in 1992 formulated an action plan, Agenda 21, a multifaceted process to address the full range of development and environmental issues involving participation of governments, international organizations and major groups in the quest for sustainable development

The publication of the Global Environmental Outlook series, GEO-1, followed by GEO-2000, the Millennium Report on the Environment, involved a participatory assessment process to review the state of the world's environment and to chart a new process for global environmental policy. The diversity and magnitude of environmental problems are outlined, with a call for more complete and precise analyses of the poorly understood linkages between human actions and environmental outcomes. Although the number of policy responses is growing, low priority continues to be afforded to the environment in national and regional planning. GEO-2000 stressed the need for the development of more comprehensive and long-term mechanisms for monitoring and assessing the effects of environmental policies on environmental quality; and for more integrated policy making and action-based programmes to serve the needs of the people.

The United Nations Environment Programme (UNEP) is mandated to produce a Global State of the Environment Report in 2002 (GEO-3) for the 2002 Earth Summit i.e., Rio + 10, and this global assessment will be enriched by producing State of Environment (SoE) reports at the national, subregional and regional levels. In 1998, the UNEP Regional Resource Centre for Asia-Pacific (UNEP RRC.AP) collaborated with the Norwegian Agency for Development Cooperation (NORAD) to carry out a process on Strengthening National Capabilities on Environment Assessment and Monitoring towards the Preparation of the Global State of the Environment Report 2002, thus linking national to regional and global initiatives.

This National State of the Environment (SoE) Report of Sri Lanka is the one of seven national reports from the above process, focusing on two Asia-Pacific subregions, namely South Asia (Bangladesh, Bhutan, Maldives, Nepal and Sri Lanka) and the Greater Mekong (Laos and Vietnam) Subregions. The Ministry of Forestry and Environment (MoFE) of Sri Lanka, which is the national implementing agency, has played a very crucial role in carrying out this participatory assessment process in soliciting input from various government sectoral agencies. Around 20 agencies and 157 individuals were involved in the process. With the substantive support from the Development, Environment and Management Associates (DEMA), the designated collaborating center by the MoFE, and regular feedback from the South Asia Cooperative Environment Programme (SACEP), this assessment exercise has been successful and instrumental in providing significant input to the ongoing South Asia SoE preparation. It aims at providing guidelines for environmental action planning, policy setting and resource allocation for the coming decades, based on a sound analysis of the state of, and trends in, the nation's environment.

Five priority key issues for the state of environment report of Sri Lanka have been identified in consultation with the Ministry of Forestry and Environment of Sri Lanka as per UNEP guidelines, and analyzed following the "pressure-state-impact- response" (PSIR) analytical framework. The same process has been followed by the other six countries, leading to the identification of their key environmental issues. These can then be addressed subsequently through action-based programmes in the next phase of the planning process.

The five key environmental issues identified for Sri Lanka are (1) land degradation by soil erosion, (2) waste disposal, (3) pollution of inland waters, (4) loss of biodiversity, and (5) depletion of coastal resources. The exploitation of natural forest for timber, coffee and tea plantation, agriculture and settlement has caused extensive soil erosion in the hill country, which not only reduces the productivity of the soil but also causes reservoirs siltation, downstream flooding and damage to the road and drainage system. The increasing urban and industrial expansion, extraction of wood and non-wood products, mining, and removal of wild animals for commercial use from the natural forest have adversely affected the biodiversity at species and genetic level leading to ecosystem degradation. Coral mining, use of inappropriate fishing method, pollution of the southern and southwestern coast from oil spills and discharges of ship waste and reduced water quality have severe impact on the coastal resources like mangrove forest, and coral reef and marine habitat. Urban wastewater from

domestic and industrial origin, excessive use of chemical fertilizers and pesticides, release of untreated industrial effluents have caused serious pollution of surface and groundwater. Also, large-scale sand mining in major rivers has caused intrusion of sea water impacting on their water quality. The volume of waste generated from the urban center, its safe disposal methods, and availability of sites for disposal are also the key issues in the country. The current practices of waste disposal and handling have serious impacts on land, water resources, air quality, and after all, the human health.

This SoE assessment for Sri Lanka provides a sound basis for the development of action plans, the next stage of the planning process, as we enter the new millenium. The report aims to provide concrete guidance for action planning, policy setting and resource allocation for the coming decades to improve the state of the environment of Sri Lanka and the welfare of her people.

UNEP will continue to provide leadership in the region for the preparation of environmental assessment reports at national, subregional, and regional level and the capacity building necessary to support these assessment activities.

Klaus Töpfer
Under-Secretary General, United Nations and
Executive Director, United Nations Environment Programme
September 2001

FOREWORD

Minister of Forestry & Environment, Sri Lanka

Sri Lanka has been endowed with ample natural resources to enrich and sustain the lives of its people. These resources favored the agricultural existence to which the early settlers were accustomed. Prudent forms of land utilization were developed and handed down from one generation to the next until they become a natural way of life of the people. These practices ensure sufficient production to meet the needs of each generation whilst preserving the resources for future generations.

The growing needs of Sri Lanka's rising population are often being met by exploiting the country's natural resources with increasing severity, an approach which needs proper attention and correction. Unless the present careless and selfish use of resources is halted and policy makers and conservationists become partners in reviving the kind of sustainable development which was indigenous to Sri Lanka many centuries ago, results will be irreversible and disastrous.

Successive governments since independence have addressed themselves to these problems and far-reaching legislation has already paved the way for corrective action. Several environmental policies and Acts have been developed during the last decades in order to provide healthful surroundings, achieve a balance between population and resources and to use the environment without degrading it. Among the more important are, National Environmental Action Plan (NEAP), Abatement Strategy, Forestry Sector Master Plan, Biodiversity Conservation In Sri Lanka A Framework for Action, Wetland Conservation Plan, Clean Air 2000 and Climate Change (activities) Action Plan.

However, evidence indicates that plans and programmes already implemented have met with limited success. The development without conservation of resources can neither sustain development nor improve the quality of life. Improved policies and management decisions which foster sustainable development, necessarily should be based on reliable data / information. Information made available to the planners and decision makers need to be timely and relevant.

It is understood that the ultimate goal of SoE reporting is to develop and update an environmental information database consisting of improved and precise data on environmental conditions, trends and their significance, status of ecosystems, the effect of human activities and the implications of human health and social economic well being. In Sri Lanka data pertaining to the environment, have been collected in parts, by various institutions, in the past. Although monitoring of the environmental conditions has been done for certain environmental parameters, it has neither been regular nor continuous. The few institutions which had been collecting environmental data have done so for purposes of assessment of environmental conditions that are of interest to the particular institution. They have not been addressed on a national or regional level. Thus, this report endeavors to fulfil the above requirement.

This SoE Report highlights five key environmental issues in Sri Lanka viz: Land Degradation by Soil Erosion, Waste Disposal, Water Pollution, Loss of Biodiversity, and Depletion of Coastal Resources. It also addressed other less crucial issues, which needs to be addresses at latter stages. In this regard the SoE Reporting can be considered as an effective tool that will assist or enhance the Implementation of NEAP. It can also be effective in providing guidance to the donor community on the areas and concerns that need to be supported.

I am pleased to notice the close collaboration, both technical and financial assistance from the UNEP Environmental Assessment Programme, and SACEP in preparing this Report which will serve as a valuable source to the planners, policy makers, and decision-makers to develop plans and formulate policies for the sustainable development of natural resources in Sri Lanka.

Mahinda Wijesekara
Minister of Forestry and Environment

FOREWORD

Secretary, Ministry of Forestry & Environment, Sri Lanka

There has been a growing recognition in recent years of the importance of periodic analysis and assessment of the State of Environment (SoE) at national, regional and global levels. This has been emphasized in Agenda 21, which emerged from the United Nations Conference on Environmental Development (UNCED), held in 1992. Sri Lanka has been endowed with ample natural resources to enrich and sustain the lives of its people. However, the sharp increase in population and the rising demands for higher living standards have placed our natural resources at risk.

It is now well understood that sustainable development cannot be achieved without integrating environmental considerations into the development process. It is, therefore, globally realized that there should be growing awareness in the understanding of the erosion of natural ecosystem, as well as degradation of human ecosystem, their causes and consequences.

The major environmental conditions and trends that will most likely constrain long-term sustainable welfare and growth in Sri Lanka are deforestation, land and water degradation, loss of biological resources, contamination of ground water, and pollution of urban environment. Within these issues all worthy needs cannot be addressed with equal effort. Practical priorities require immediate focus on correcting environmental conditions most likely to cause grave damage to the people at present and also in the future. Preventive and corrective environmental management measures or actions can enhance national wealth and the human environment.

The development of an appropriate framework for effective environmental management requires a clear understanding of the current state of the environment. The State of the Environment of a country refers to the prevailing conditions from two perspectives; i.e. biophysical and socio-economic conditions. It also provides an overview on the outcomes of responses such as policy initiatives, legislative reforms, and changes in public behavior. The Chapter 40 of Agenda 21 on "Information for Decision Making" underlines the importance of an improved availability of information on all aspects of environment and development in decision making towards sustainable development. In addition, it also emphasizes the need for "improved collection as well as presentation of data and information".

Decision-makers need reliable data on key environmental issues such as water pollution, loss of bio-diversity, erosion of land, and other key indicators. Without adequate and accessible information, there may be irreparable damage done to the natural eco cum social system and their sustainability. The SoE report can play an important role in fulfilling this requirement in generating certain planned action and the necessary investments required for implementation. It should also provide policy makers a basis for institutional re-orientation and a new approach in environmental management.

I would like to take this opportunity to thank all these who contributed towards this exercise by providing the necessary data and also by providing comments on the various sections of the report. I very much appreciate the inputs of the Resource Persons who reviewed each chapter of the draft report in detail, which enhanced the quality of the report.

I hope this exercise would be an important effort to create awareness and a common goal towards sustainable development.

N Pathmanathan
Secretary
Ministry of Forestry and Environment

ACKNOWLEDGMENTS

UNEP would like to thank the many individuals and institutions who have contributed to the preparation of Sri Lanka: *State of the Environment 2001*. They included individuals in Government departments, intergovernmental organizations, academic institutions, and voluntary organizations. A full list of contributors, reviewers and participants of the national State of the Environment training and consultation, are included in the Appendix. Special thanks are extended to:

National Implementing Agency
Ministry of Forestry and Environment (MoFE), Sri Lanka

National Collaborating Centre
Development, Environment and Management Associates (DEMA), Sri Lanka

Funding
The Norwegian Agency for Development Cooperation (NORAD) provided the required financial support needed to the Strengthening Environmental Assessment and Monitoring Capabilities in South Asia and Greater Mekong Subregion (SEAMCAP) Project under which the Sri Lanka: State of the Environment 2001 has been prepared.

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Part I Executive summary

PART ONE : EXECUTIVE SUMMARY

1.0 Introduction

Sri Lanka is a tropical island in the Indian Ocean with a history of continuing human occupation for over 25 centuries. The country's total population is around 19 million and with a population density of 280 persons per sq km is one of the highest in the world. Over 40% of the people are engaged in activities directly dependent on the environment and about 25% people live in urban or semi urban areas. The development efforts of successive governments during the last five decades have led to an increase in the standard of living of its people. The table below compares Sri Lanka with some of the South Asian countries.

The high population density and sustained efforts to improve living standards have created tremendous pressure on the natural environment of the country.

Sri Lanka : A Comparative View

Country	Population Density/ km2	GNP/ pc US$ (1997)	Population Growth Rate	Life Expectancy
Sri Lanka	294	820	1.2	71
Nepal	164	220	2.4	58
India	336	450	1.8	62
Pakistan	175	470	2.5	61
Bangladesh	981	370	1.6	58

Source: World Bank(1998)

The challenge is to set the right balance between development and the environment, to ensure sustainable progress.

As an important preliminary initiative, the Ministry of Forestry and Environment (MoFE), in association with government agencies responsible for managing the environment and experts on environment identified five key environmental issues as priorities in the SOE. Sri Lanka faces many other environmental problems, yet these issues have become increasingly significant from an ecological as well as from a socio -economic stand point. These issues necessitate urgent corrective action, which involve policy interventions, effective management including inter-agency coordination, enforcement of laws and substantive investment in implementing mitigatory measures.

1.1 Land Degradation due to Soil Erosion

Land is the most vital and heavily threatened natural resource in Sri Lanka. Degradation of land due to soil erosion is of much concern because of its consequences on agriculture, which is a major contributor to the country's GDP. It is estimated that about 5-10 mm of topsoil is lost every year. In the hill country, where several large rivers originate and critical watersheds are located, erosion is acute. Several direct and indirect factors cause soil erosion.

- "Chena cultivation" (slash and burn cultivation), practiced in about 15 percent of the total land area, is a major cause.
- Insecure land tenure, with rotation of cultivation by plots and by season, also causes degradation of land because land is exploited to the maximum with minimum conservation measures.
- The study conducted by the Hector Kobbekaduwa Agrarian and Training Institute (HARTI) revealed that poverty has a direct relationship to the extent of soil erosion.
- Another factor influencing erosion is the increasing rate of deforestation mainly by commercial loggers.
- The cultivation of erosive crops such as potatoes, tobacco and vegetables has led to severe erosion particularly in hilly areas.
- Sand and gem mining, construction of roads, housing projects and other infrastructure development activities, have also contributed to soil erosion.

Tea plantations and large- scale development projects such as the Mahaweli Development Programme have led to extensive soil erosion in the hill country. Impacts of soil erosion vary with the type of crop and the geographic location. Critical watersheds where several large rivers originate have been adversely affected.

- The degraded soil in tea and other commercial plantations require the application of large quantities of chemical fertilisers leading to higher costs of production.
- Floods, land slides and siltation of large reservoirs are some of the indirect effects of soil erosion.

Some recommendations to remedy these problems are:

- Strengthening the legal and institutional base with necessary amendments to the Soil Conservation Act, and the establishment of a strong institutional mechanism under the leadership of MoFE, with appropriate linkages with provincial agencies
- Establishment of a strategy to wean rural people away from land-based employment particularly in the critical watersheds in the central highlands
- Effective enforcement of land use zoning laws and regulations
- Implementation of appropriate forestry programmes, in vulnerable areas
- Investment on research and development on soil conservation practices
- Development of a comprehensive data base accessible to all stakeholders

1.2 Waste Disposal

Management of solid and liquid waste are critical issues particularly in urban areas and around industrial sites. Although Local Authorities (LAs) are responsible for collection and disposal of waste, inadequate resource availability has hindered their work. The daily collection of waste is around 2,500 tons of which the Western Province accounts for 57%. A large quantity of hazardous and non-hazardous waste material is generated at industrial and hospital sites. It is estimated that waste generation would continue to increase at a growth rate of 1.2%. The present method of solid waste disposal is mainly open dumping in low-lying lands. Numerous impacts of waste disposal have been identified:

- Reduction in flood retention areas, pollution of wetland habitats, pollution of surface and ground water
- creation of malodorous environments facilitating insect/mosquito breeding and other impacts on health

Some LAs have initiated waste treatment practices such as composting of waste at household level, recycling of waste materials, incineration and landfills.

Recommendations to resolve waste management problems and to improve the present system include:

- Adoption of integrated waste management systems which would provide a rational and coherent waste disposal mechanism
- Establishment of central and regional institutions to coordinate waste management
- Effective enforcement of laws and regulations
- Encouraging the participation of communities and the private sector in waste management and
- Promoting entrepreneurs in recycling waste, especially polythene, and in composting.

1.3 Pollution of Inland Waters

The principal source of surface and ground water is rainfall. Water pollution in the country arises from agricultural practices with extensive use of agro-chemicals and fertilisers, urbanization and industrialization resulting in the release of untreated industrial effluents, dumping of domestic waste and flow of sewage into waterways.

- The high concentration of population and migration towards urban centers such as the Colombo Metropolitan area and other cities has led to pollution through discharge of waste into waterways.
- About 80% of the industries are concentrated in the districts of Colombo and Gampaha. Some of these industries are high polluting such as textile dyeing, bleaching, food processing, leather tanning, metal finishing, agro and mineral products.
- Many industries have no waste treatment facilities.
- Eutrophication or the process of nutrient enrichment of stagnant waters due to accumulation of fertilizer used in upland areas, has affected several large inland reservoirs.
- Use of chemical fertilizers resulting in high nitrate contents in drinking water wells, mostly in agricultural areas.
- Water is also polluted through pit latrine soakways.
- Pollution of inland water affects human health through the spread of water borne diseases and adversely impacts on fish, birds, other living organisms and even entire ecosystems.
- The proposed Water Resources

Management Policy and Water Resources Management Act will provide a sound legal basis for the management of inland water bodies free from pollution. Those will be supplemented by strategies proposed under the National Environmental Action Plan (NEAP).

Recommendations to address these issues are:

- Controlling the use of agro-chemicals and chemical fertilisers and encouraging organic farming with measures for bio-control of pests and insects and use of compost fertilisers
- Introducing sound catchment management practices to prevent eutrophication
- Establishing proper sewerage facilities initially in urban areas
- Introducing appropriate solid waste management and waste water disposal techniques
- Locating high polluting industries in industrial zones with central water treatment and waste management practices.

1.4 Loss of Biodiversity

Sri Lanka is endowed with rich biodiversity, which is threatened by increasing population and expansion of the human environment

- Natural forest ecosystems are adversely affected by logging especially of rain forests. Montane and pristine forests have suffered less exploitation. Grasslands have also been affected by land clearing for agriculture, housing and by over grazing
- Inland aquatic systems suffer deterioration as a result of deforestation, soil erosion, urban and sub-urban effluent discharges and reservoir construction altering the natural river flows, gem mining and invasion by exotic plants and animals
- The increasing human-elephant conflicts indicate that the largest mammal of the country is severely endangered
- Over 480 flowering plant species and 90 fern species have been assigned threatened status
- Among animals, about 75% of vertebrate groups and about 50-100% invertebrate groups are under threat

Pressures on biodiversity include:

- Increasing demand for land for urban, agricultural and industrial development and expansion of such activities. These invariably change land use patterns
- Extraction of forest products affects biodiversity at species and genetic levels
- Mining for precious stones and sand mining (largely illicit mining)
- Removal of wild animals for commercial purposes
- Over visitation to wild life and natural reserves

Programmes introduced to protect biodiversity are:

- Establishment of protected areas, buffer zones and boundary marking
- Laws and regulations supportive of conservation
- Acceptance by Government of the document titled "Biodiversity Conservation in Sri Lanka, a Framework for Action"
- Current programmes on extension, awareness creation, education and training programmes, supplement the implementation process
- Efforts on valuing natural resources have facilitated the reformulation of policies and strengthened implementation

Recommendations for improvement of biodiversity include:

- Development of conservation areas, boundary marking and zoning strategies,
- Capacity building of field staff of relevant agencies
- Regulating visitors to conservation areas
- Periodic review and updating of policies, programmes and strategies
- Fostering research with national and international linkages
- Development of recreational facilities, eco-tourism and education based on biodiversity
- Rehabilitation of degraded areas,
- Expansion of the process of valuation of natural resources
- Facilitating community participation in conservation management of natural ecosystems

1.5 Depletion of Coastal Resources

Sri Lanka is endowed with a coastline of 1585 km. The coastal region includes an area of land and water where ecological processes of both land and maritime environments become inter-linked and are influenced by human activities. Pressures on coastal resources are:

- Concentration of population in coastal areas: 32% of the total population, 65% of the urban population, 90% of industrial units and 80% of tourist infrastructure are located in the coastal zone leading to depletion of coastal resources
- The tiger prawn export industry, particularly in the north-west coast, has caused severe damage

to mangroves and other ecosystems

- Collection of non-edible aquarium species harvested for export purposes mainly from inshore coral reef areas has affected the coral reef ecosystems:
  - Coral mining and dynamite blast fishing impact on coastal ecosystems
  - Mechanised fishing techniques have drastically reduced the fish stock
  - Expansion of tourism, development of urban infrastructure, waste disposal shipping and transport and local power plant discharges are some activities that disrupt the coastal ecosystem

Adverse impacts on the coastal resources include:

- Erosion of coastal area (about 1 meter per year) due to river damming, sand mining, collection of coral rubble and removal of coastal vegetation
- Salinisation of paddy land due to reduction of flood buffering capacity of mangroves, lagoons and estuaries
- Degradation of coral reefs as a result of human activities
- Several policy and legal interventions introduced over the past years for the protection of coastal resources have proved effective
- International conventions have supplemented actions taken to protect the coast.

It is recommended that the existing legal framework be strengthened, the laws and regulations be effectively enforced, the policies and programmes be regularly updated and awareness raising and training activities be organised for various groups on stakeholders and conservation of coastal resources.

Conclusion

The State of Environment Report focuses on five critical environmental issues facing Sri Lanka.

It has analysed the pressure, state and impact of a variety of factors that impinge on the key environmental issues identified as crucial for Sri Lanka, and recommended remedial or mitigatory measures.

MoFE has developed important strategies and action plans for the effective management of Sri Lanka's environment. This Report will further strengthen these significant initiatives and assist the Ministry in its pivotal role of harmonising environmental concerns with the country's development goals.

Part II

Sri Lanka's Environment
An Overview

PART TWO : SRI LANKA'S ENVIRONMENT AN OVERVIEW

2.1 Background

Sri Lanka, with an area of about 65,610 square kilometers lies between 6°N and 10°N latitude and between 80°E and 82°E longitude. A central mountainous massif and a vast plain surrounding it, define the topography of the Island. There is a significant temporal and spatial variation in the Island's climate. The annual temperature in the coastal belt ranges from 26.0°C while in the central highlands it ranges from 15°C to 19°C. As a tropical island there is little temporal variation in temperature. The average annual rainfall varies from1000 mm in the arid zones in the southeastern and northwestern parts of the island to over 5000 mm in a few places on the southwestern slopes of the central highlands. The 3000 mm isohyet divides the country into the Wet Zone, covering the southwestern part, and the Dry Zone which is spread over the vast plains to the north and east of the highlands.

The population in 1981 was 14.8 million and is now estimated to be near 19 million. It is projected to increase to 23.1 million by 2031. The distribution of the population is uneven with nearly 60% concentrated in the Wet Zone, the more developed part of the country.

Over 72% of the population live in rural areas. However, owing to the small size of the country, most cities and towns are within easy reach for most people.

Sri Lanka's GNP per capita is over US$ 800 which is ahead of some South Asian countries.

Location of Sri Lanka

Cost of Environmental Damage -1992

Category	Issue	Damage Estimated Rs. Millions	As % of GNP
Green	Forest/Biodiversity	-	-
	Forest Depletion	542.0	-
	Agriculture/Land Degradation	-	-
	Soil Loss (Hill Country)	3426.5	-
	Chena Cultivation	1500.0	-
	Coastal Zone	-	-
	Mangroves	50.0	-
	Sub Total	*5518.5*	*1.3*
Brown	Urban Industrial	-	-
	Air	64.5	-
	Solid Waste	100.0	-
	Water	2701.0	-
	Sub Total	2865.5	0.7
Energy	Power Generation	1817.3	0.4
Total	**Total Damage**	**10201.3**	**2.4**

Source: Report to the the CIEDP and CEPOMs, MoFE (1998)

2.2.1 Land Resources

State

Land is one of the most important natural resources of Sri Lanka. 37.9% of the people are still dependent on land-centered activities for their sustenance. Of the total land area of 65,610 sq. km, 2,905 km comprise inland water bodies which include man made reservoirs. Provinces located the wet zone i.e. Western, Central, Southern and Sabaragamuwa are smaller in extent but have a higher population density while the provinces in the dry zone are large in extent but records a relatively a low population density

Lack of precise valuation techniques for biodiversity , coastal resources depletion and land degradation, grossly undervalues the price Sri Lanka pays for environmental damages

Increasing pressure of population on land has led to:

- A rapid decline in the land: man ratio from 2.25 ha per person in 1880 to 0.38 ha in 2000, and
- Widespread landlessness forcing people to encroach upon state land.

Land use in the country is classified into seven categories. The share of agricultural land, is about 57% and the built up area less than 0.5%.

Population density is highest in the wet zone provinces

Over 80% of the land is directly or indirectly owned by the state.Retaining control of land by the state even after alienation is considered a restraining factor in the conservation of this resource.

Land use patterns indicate that the Wet Zone is almost exclusively devoted to agriculture, (paddy and plantation crops) and urban development (homesteads, towns and cities) Most of the forest, range lands and paddy lands are located in the Dry Zone

Pressure

The primary pressure on land resources is the high density of population. A series of secondary pressures follow:

Extent of Land, Water and Population Resources

Province	Total Area Km²	Land Area km²	Inalnd Water Bodies km²	Density
Western	3,684	3,593	91	1,311
Central	5,674	5,575	99	415
Southern	5,544	5,383	161	444
Northern	8,884	8,290	594	288
Eastern	9.996	8,290	635	359
North Western	7,888	7,506	382	168
North Central	10,472	9,741	731	142
Uva	8,500	8,333	165	136
Sabaragamuwa	4,968	4,921	47	115
Total	**65,610**	**62,705**	**2,905**	

Source: Statistical Compendium, Department of Census & Statistics, (1998)

- Inappropriate land management practices in the agricultural sector and absence of soil conservation measures has led to land degradation.
- Chena cultivation (shifting cultivation) with inadequate fallow periods and neglected soil conservation measures is responsible for degrading about one million ha. of land.
- Expansion of industries using land based resources such as the brick and tile inustry, gem mining and mining for minerals have degraded land in many parts of the country. Most of these industries do not restore the land after exploitation.
- Expansion of settlements, urbanisation and industrialisation: Although the urbanisation rate is low in Sri Lanka, 'urbanism' or transformation of the rural society into an urban community, is taking place. Thus some urban environmentalproblems such as disposal of solid waste, domestic sewage, waste oil, polythene etc. are also present in rural areas though at a different scale and magnitude:

  - Encroachments of environmentally sensitive lands by landless people in rural areas is for

Land Use Types

Land Use Types	Extent in Hectares
Built up Lands	29,190
Agricultural Lands	3,710,880
Forest Lands	1,759,840
Range Lands	593,520
Wet Bodies	61,810
Barren Lands	77,480
Total	**6,523,240**

Source: Statistical Compendium on Environmental Statistics Sri Lanka: 1998, Department of Census and Statistics

Agriculture retains its position as the major land-use sector

subsistence farming, whilst agricultural businessmen, taking advantage of higher prices obtainable for some crops (e.g. potatoes) encroach

even environmentally sensitive lands. The following table provides a provincial breakdown of encroachments.

- Deforestation is an outcome of many factors such as encroachment, illicit felling of timber, forest burning, clearing of forests for agricultural and other purposes
- The ill-defined land tenure system is skewed towards state ownership. It is estimated that about 80% of the land is under state ownership since independence. Over 25% of the people live on land alienated by the state.

In addition to the above natural pressures on land resources (at times initially induced by human activities) other factors have been identified:

- Natural soil erosion takes place on sloping hills even with the best of land management practices. The current preparatory practices in paddy fields in hilly areas lead to erosion with consequent loss of soil fertility.
- Coastal erosion is primarily due to excessive removal of river sand, which once replenished the beaches in the southwestern coast.
- Salinity in some low-lying areas in the country are caused by salt-water intrusion during periods of low water levels in rivers. Excessive sand mining contributes.

Provincial Breakdown of Encroachments 1979

Province	Number of Encroachments	Extent of Land Encroached (ha)	Extent of Reservations Encroached (ha)
Western	28,136	8,973	2,065
Central	34,534	15,953	4,978
Southern	74,665	31,128	5,960
Northern	47,903	42,213	4,251
Eastern	92,641	71,780	8,008
North Central	107,656	70,105	12,601
North Western	111,868	78,688	10,283
Sabara-gamuwa	37,299	16,602	3,402
Uva	70,600	45,918	4,124
Total	**605,302**	**381,362**	**55,675**

Source: Report of the Land Commission - 1987

The Survey of Encroachments on State Lands in 1979 estimated that about 500,000 families have encroached on 6% of the land area.

- Water logging has been identified on a smaller scale in irrigation systems. Large scale filling of lowlands in urban areas especially in Colombo has created new water logged areas.

46% of the total land area is estimated to be affected by water erosion

Soil erosion by water is the major cause of land degradation. While the soil erosion rate varies according to agro-ecological regions and land use patterns, about 46% of the total land area is estimated to be affected by water erosion.

There are factors outside the purview of natural resource management agencies that contribute towards the degradation of land. The lack of appreciation of the linkages between macro-economic policies and land degradation is seen, for example, in the imposition of high tariffs for the import of potatoes resulting in the creation of artificial prices in the local market. Farmers are thereby induced to grow this crop even on environmentally sensitive lands.

Typical Site of Soil Erosion in the Hill Country

Soil Erosion Rates

Agro-eco Region	Land Use	Soil Loss (t/y/ha)
Mid country Wet	Seedling tea with no conservation	40.00
	Well managed tea with conservation	0.24
	Home Gardens	0.05
Mid Country Intermediate	Tobacco with no conservation	70.00
	Capsicum with no conservation	38.00
Up Country Wet	Clean weeded VP tea	52.60
	One year old tea with mulch	0.07
Low Country Dry	Cotton	22.00
	Sorghum	21.00

Source: Statistical Compendium on Environmental Statistics Sri Lanka 1998; Department of Census and Statistics

2.2.2. Water Resources

State

The ancient hydraulic civilization in Sri Lanka was founded on harnessing the abundance of water resources. Expanded agricultural sector and growing industrial and urban sectors have steadily increased the demand for water resources on the one hand and negatively affected the quality of water bodies on the other.

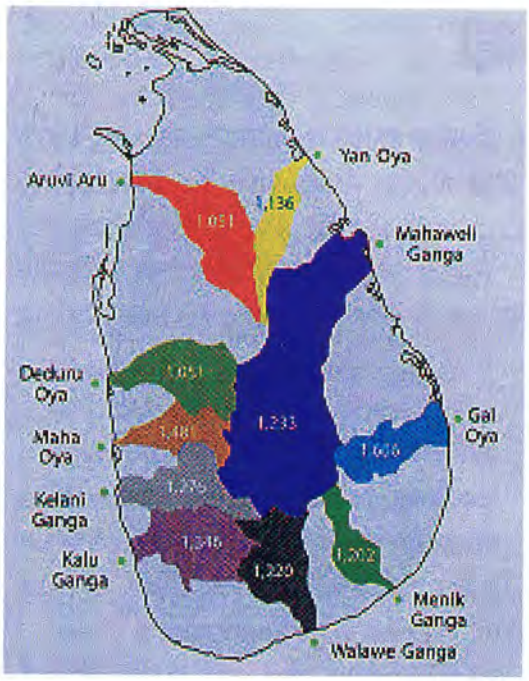
There are 103 rivers flowing in a radial pattern from the high watersheds. The longest river, Mahaweli, drains 16% of the Island and transports water from the wet zone to the dry zone. Other water bodies include numerous wetlands, major and minor irrigation systems and significant groundwater resources.

The annual renewable freshwater resources amount to 2,341 cubic meters per capita ('Water Resources 1998/99' Water Resources Institute 1999) However, recent studies undertaken by the International Water Management Institute (IWMI) reveal that aggregate figures mask the significant spatial and temporal variations in water supply and demand. 79% of the water in the wet zone escapes into the sea as against 51% from the dry zone (Sri Lanka Water Vision 2020). Water is mainly used for irrigation, hydropower,

domestic purposes and for industry. Irrigation is the single largest water user in the country.

Only 14% of the rural population has access to piped water compared to 75% of the urban population Non-revenue water in the pipe borne water supply is estimated at 40% by the National Water Supply and Drainage Board (NWSDB). This is mainly due to poor maintenance, high connection costs (which leaves the poorer sections of the community dependent on stand posts), leakages and illegal consumption.

Water Resources Evaluation - (kg/m³)
June to November 1999



(Source: NWSDB Master Plan)

Combining satellite estimates of water use with ground-based rain fall data enables a rapid evaluation of available resources. The volume of water leaving the ten major river basins in Sri Lanka is shown above.

Pressure

Population growth is the primary pressure on both the quantity and quality of water resources. The demand for potable water will increase with improvement in the standard of living and the growth of population. The most significant pressures on water resources are:

- An increased demand for water from the expanding industrial sector. The manufacturing sector contributes about 25 % to the GNP and will continue to develop in the future. The present consumption by industry of approximately 3 million cubic meters a day will increase substantially
- Urbanisation and the consequent generation of waste, especially sewage, are major causes of water pollution in urban and suburban areas. Most towns in the country do not have sewage treatment plants. Open dumping of waste and the resultant leachate has contaminated water in the vicinity of these dumps. Faecal contamination of water is observed in most urban and suburban areas in the Western Province
- Industrial effluent is a another source of water pollution. The lower Kelani River, Beira Lake and Bolgoda Lake are highly polluted due to discharge of sewage as well as industrial waste. A large number of Local Authorities do not have facilities to treat waste and as a result it is dumped onto open ground or into waterways

Source of Water Supply -1998

% of Population - 1998	Urban 5.61 million	Rural 13.04 million	Total 18.65 million
Served by piped water supply	75%	14%	32%
Served by dug wells	10%	11%	11%
Served by protected dug wells	10%	40%	24%
Other	5%	35%	33%

Only 14% of the rural population and 1/3 of the total population has access to pipe borne water

Source: National Water Supply and Drainage Board (NWSDB)

- At present, the agricultural sector accounts for 90% of water consumed in the country. Although the relative share of water used by agriculture is likely to decline in the future, it may continue to be the dominant user
- The increasing use of agricultural chemicals i.e. fertiliser, weedicides and pesticides is a major cause of deterioration of the quality of both surface and underground water. Jaffna peninsula, with its very high ground water table, has recorded nitrate concentrations of over 200 mg/1 of NO3
- Oil pollution is a problem in most urban and suburban areas where motor garages and service stations dispose of waste oil into drains. There are over 100 such service centres in Colombo alone
- Groundwater resources are used extensively in the dry zone. During the past two decades, tube wells have been installed to access deep groundwater. An estimated 40% of tube wells dug for drinking purposes during the last decade have been abandoned due to contamination with iron, manganese, fluoride and subsidence of water levels
- An interesting finding is the decline of the rainfall in the upper catchments. According to some studies (Hamamori, 1988, Madduma Bandara and Kuruppuarachchi, 1988), the annual rainfall in Nuwara Eliya has declined by 20%. This is an indication that the total water available in the upper catchments has declined affecting both electricity generation and irrigation.
- Salinity in irrigated paddy fields, though small in extent, appears to be on the rise. However, the bigger problem is the intrusion of salt water into rivers especially in the western coast. Excessive sand mining, which has led to lowering of the riverbed, is the primary cause. Salt water intrusion is already threatening Colombo,s water intake at Ambatale from the Kelani River.

2.2.3 Air

State

The circulation of air and sea breezes experienced in the Island continuously refreshes the air. During monsoons, which cover more than eight months of the year, new air masses frequently move over the Island.

However, with industrialisation, air pollution has become a serious issue in urban areas in the Western Province. A 10% rate of increase per year is estimated in sectors such as transport, power and energy and industry, which use fossil fuel and will aggravate air pollution problems.

Per capita energy consumption in Sri Lanka is half that of India and Pakistan and more than twice that of Bangladesh.

Of a total installed electricity generating capacity of 1564 megawatts, 1,137 comprise hydro power and 427 megawatts thermal power. The annual electricity growth for the next 20 years is estimated at 8%. The annual demand is projected to grow from 3.803 gwh in 1993 to 14,360 gwh in the year 2013 and much of this increase has to be met through thermal power generation.

Hydro and Thermal Electricity Generation

Year	Units generated Hydro	(GWH) Thermal
1986	2645	7
1990	3145	5
1994	4089	275
1998	3908	1346

Source: Ceylon Electricity Board-1999

More than 2/3 of the fuel requirements are derived from the county's natural resources

Biomass is used for both domestic and industrial purposes.Large-scale industrial uses include the manufacture of bricks and smoked sheet rubber. The Forestry Sector Master Plan anticipates a demand of 97 million tonnes of biomass by 2020, while the supply is expected to be about 100.1 million tons if present practices continue. Biomass utilization leads to CO2 emissions. This also causes indoor air pollution leading to respiratory diseases particularly in ill ventilated rural homes using firewood for cooking.

Consumption of Energy-1996

Source	Consumption %
Petroleum products	25.3
Fuel wood	67.8
Electricity	5.0
Others	1.0

Source: Ceylon Electricity Board 1996

Major air pollutants are oxides of nitrogen (NOx) oxides of sulfur (SO2), carbonmonoxide (CO) and hyd rocarbons including aromatics, toxic metals and particulate matter (PM).

Air pollution results in several problems:

- Health hazards to children
- Health impacts on senior citizens
- Adverse effects on building material, structures, agriculture, livestock, cultural and archeological monuments.

Several state agencies have been engaged in quantifying the problem by monitoring wet and dry deposition of air pollutants. These include the National Building Research Organisation NBRO Central Environmental Authority (CEA), Atomic Energy Authority of Sri Lanka (AEA), Industrial Technological Institute (ITI), Tea Research Institute (TRI), and the Universities of Colombo, Peradeniya, Kelaniya, Sri Jayawardenapura, and Ruhuna.

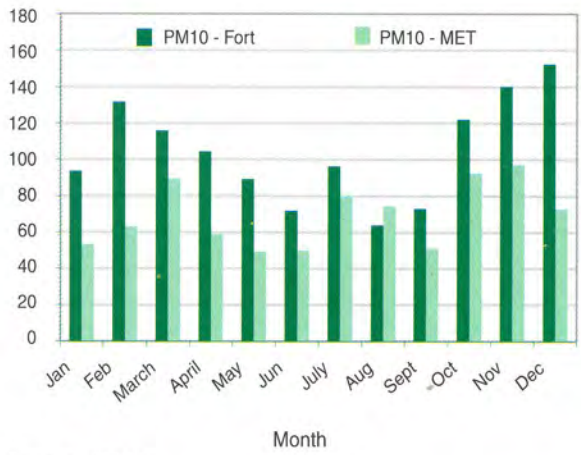
The demand for energy is increasingly met with fuels

The NBRO and the CEA are monitoring air pollution using two fixed and one mobile air quality monitoring laboratory units. Results from 1996 indicate that the levels of sulfur dioxide and ozone exceed ambient standards stipulated by the CEA during certain periods of the year and that restorable particulate (PM-10) in Colombo is widespread.

Pressure

The main pressures on the atmosphere are the three prominent fossil fuel consumers: transport, industry and power generation .

Maximum Concentration of PM 10 in Colombo Air in 1999(µg/m³)



Source : NBRO

Vehicle Emissions

Source: Statistical Compendium on Environment Statistics Sri Lanka (1998)

Vehicle emissions are a major cause of air pollution. Vehicle imports in 1999 shows a welcome decline

- Vehicles powered by fossil fuels exert the primary pressures on air resources. The vehicle fleet has increased rapidly since the early 1990s. Excessive consumption of fuel, due partly to lack of proper motor engine maintenance and partly due to chronic traffic congestion further aggravates the problem. The total vehicle population in 1999 stood at 1.6 million vehicles.
- A large number of industries use fossil fuel as a source of energy. Many of these are located in and around Colombo.

Registration of New Vehicles

Type	1994	1995	1996	1997	1998	1999	2000
Buses- SLCTB -Private	-	-	310	459	552	859	894
Private cars	3,823	1,699	1,169	1,600	2,796	3,752	1,404
Three Wheelers	12,721	18,867	17,664	15,045	22,689	25,238	25,238
Dual Purpose	4,969	12,661	13,052	10,402	16,547	14,706	11,656
Motor cycles	9,798	11,175	14,250	16,293	18,455	9,818	7,928
Goods /Tpt. Vehicles	36,791	34,209	31,955	36,755	42,089	42,497	39,98
Land Vehicles	5,195	7,293	5,600	5,561	8,702	13,360	8,682
	7,160	9,124	8,330	7,652	8,415	9,291	7,530
Total	**80,457**	**95,028**	**92,330**	**93,767**	**120,245**	**117,.521**	**103,319**

Source: Department of Motor Traffic(2001)

Consumption of Total Fossil Fuel Imported

Sector	Percentage
Transport	80
Industry	12
Power	8

Source: Ministry of Power and Energy (1998)

- Having exhausted most of its economically viable hydro-power generation potential, Sri Lanka has had to turn to thermal based electricity generation. Most thermal power plants are located in and around Colombo. Sulphur emitted from coal power plants in South India can be brought into the country as acid rain during the monsoons.

Sri Lanka's protected area system compares favourably with other South Asian countries

2.2.4 Forests and Wildlife

State

The forest cover, which is around 22% of the land area, is spread over both the wet and the dry zones. The distribution of forests closely follows the pattern of climatic variation in the country. Two main types of forests can be identified.:

- Tropical montain forests are typically found at elevations above 1,200 meters in the montane wet Zone.
- Mixed evergreen forest cover is about three fifths of the land area in the country. A special characteristic of evergreen forests is the presence of a large number of tree species which are endemic to Sri Lanka.

Over 90% of the natural forests are controlled by state agencies such as the Forest Department and the Department of Wildlife Conservation (DWLC).

Most forests come under the protected area system with 43 protected areas covering 783 sq.km. This represents 11.9% of the total land area.

The total area declared under the Fauna and Flora Ordinance is 415,000 ha. of which nearly 75% comprise national parks (approximately 205,000 ha).

Of an extent of 2.3 million ha within the custody of the FD and the DWLC, only an extent of 1.3 million ha has a close canopy cover.

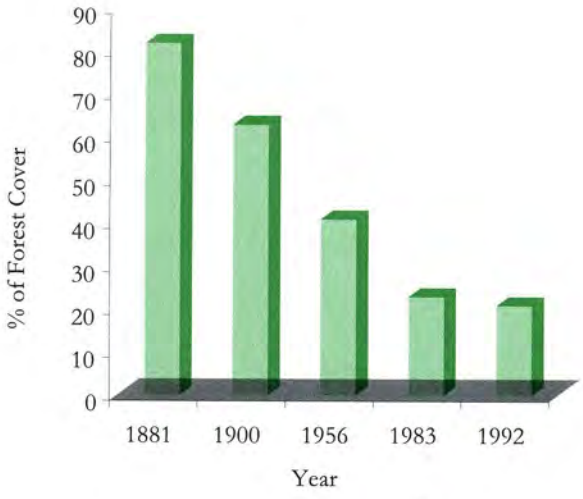
Forest cover has been steadily declining over the years, from 80% of the land area in 1881 to 24% in 1992. The average annual rate of deforestation between 1956 and 1992 has been over 36,000 ha.

Total protected Area

Country	Area Sq.km	As a % of the total land area
Sri Lanka	7,837	11.9
Bangladesh	968	0.7
India	131,596	4.2
Pakistan	36,550	4.6
Bhutan	9,061	19.4
Maldives	0	0

Source: Sri Lanka Forestry Sector Master Plan 1995

Forest Cover Decline



Source: Data from MoFE

Pressure

Deforestation is caused by a multitude of pressures:

Within 100 years forest cover has declined from 80% to 22% of the Land Area

- **Planned deforestation:**
  Vast forest areas were converted into agricultural lands under several irrigation projects such as Gal Oya and Mahaweli Development Programmes and agricultural projects such as Pelwatta and Sevenagala sugar plantations. Some forest areas were also inundated by large reservoirs such as Gal Oya, Randenigala and Maduru Oya. The implementation of these projects resulted in a loss of at least 37% of forest from 1983-1992.
- **Illicit felling of timber:**
  Illicit felling for domestic and commercial purposes is widespread in spite of stringent laws with resultant damage to the forest ecosystem.
- **Firewood collection:**
  In rural areas firewood is the principal fuel for cooking. Persons living along borders of forests find it convenient to obtain their firewood from the protected forest reserves. The process also involves the felling of trees. Small forest patches

that sustained a multitude of springs have been destroyed.

- **Chena cultivation:**
  15% of the land area has been abandoned after shifting cultivation and has not regained forest cover.
- Large forest patches in the hill country have been cleared for erosive crops like potato.
- Fires are a major threat to forests and biodiversity especially in the midcountry
- "Over collection" of specimens of some indigenous varieties of flora for scientific purposes has been observed in recent years. When the medicinal value of a species becomes well known, exploitation is rapid and the species is threatened. "Kotala Himbutu" is a good example of such over exploitation.

Tropical Rain Forest

Source: MASL File Photos

2.2.5 Coastal Resources

State

Sri Lanka has a coastline of 1,585 km. The coastal zone/region is significant not only for its natural resources but also as an important area of human activity and contains:

- 24% of the land area
- 30% of the population
- 65% of the urban area
- 65% of industrial output the nation,s principal transportation structure
- 80% of fish from near-shore fishing
- habitats critical for sustained production of fisheries, coral reefs and brackish wetlands
- richest biodiversity reserves
- a large number of river basin estuaries and lagoons, many of which are lined with mangroves, covering about 160,000 ha.

In addition, the coastal region is important for several other reasons:

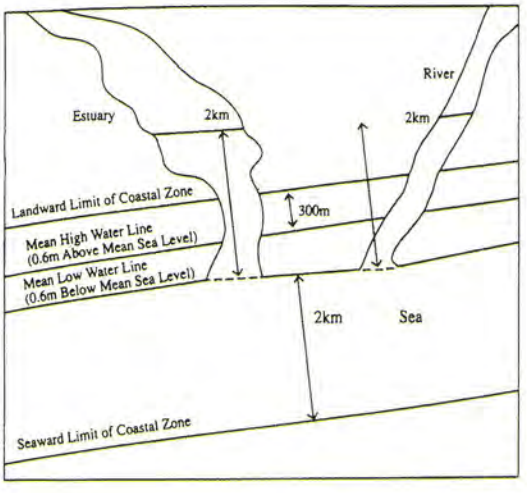
- Sri Lanka's coasts and beaches are among the most scenic in the world and are an aesthetic resource
- Coasts provide important minerals including sand and ilmenite
- The coastal region functions as an important sink to most waste generated in the country

The most pressing problems in the coastal zone are:

- Coastal erosion
- Coastal pollution

These problems are most acute along the western coast.

Coastal Zone



Source: CCD

Pressure

The main pressures on coastal resources are:

- Coral mining :Coral provides about 90% of lime for the construction industry and despite stringent laws, coral mining continues in offshore reefs. However, it is observed that the amount of coral mined from Ambalangoda to Dickwella has declined from over 18,000 tonnes in 1984 to

4020 tonnes in 1993. Inland coral mining has increased to cover the difference.

- Large-scale clearing of coastal vegetation for aquaculture and other uses:
- Mangroves, covering about 16,000 ha, have been used as timber and fuel wood over the years and also converted into aquaculture sites and human settlements
- Sand mining in beaches and rivers:Sand mining contributes directly to beach erosion. It is estimated that 1.6 million cubic meters were mined in 1991 from rivers flowing into the sea from Puttalam to Dondra Head. The amount of sea sand removed from this stretch was 146,170 cubic meters (De Alwis, 1991)
- Haphazard constructions:Private dwellings, commercial buildings and tourist resorts have been built in large numbers along the coast. Many of these projects have paid scant attention to safeguarding coastal habitats and aesthetic considerations. The Hikkaduwa resort region is now facing the repercussions of unplanned development with a drop in tourist arrivals.
- Dumping of waste (domestic sewage, waste oil and solid waste) directly into the sea or into rivers :Untreated sewage and industrial waste are discharged into waterways. For example in 1991 between 67,500 cubic meters and 90,000 cubic meters of Colombo,s untreated sewage was dumped daily into Kelani River (Baldwin, 1991) Although less in magnitude, the same phenomenon is observed in other rivers as well.

The two ocean outfalls of the Colombo sewage system discharged over 100,000 m2/day in 1991 (Dassanayake, 1994)

Runoffs of agricultural wastes such as agrochemicals, drain into rivers, estuaries and lagoons and are ultimately, deposited into the ocean.

Waste oil from tankers, mechanized boats and over 100 service stations also pollute the coast.

Solid waste is dumped directly into beaches or brought in by rivers. Some areas, including popular beach resorts, are littered with solid waste making them aesthetically unpleasant.

2.2.6 Biodiversity

State

Sri Lanka is endowed with rich biodiversity and is considered one of the biodiversity "hotspots" in the world.

Sri Lanka has a rich ecosystem diversity for its small size. Its natural ecosystems include:

- The marine and maritime or coastal ecosystems influenced by the sea
- The natural forest ecosystem
- The natural grassland ecosystem
- The inland wetland ecosystem

The following ecosystems are internationally recognized:

- Sinharaja as a World Heritage Site and an International Man and Biosphere Reserve
- Hurulu Forest Reserve as an International Man and Biosphere Reserve
- The Western Ghats and South West Sri Lanka as a group, is one of the 25 Biodiversity Hot Spots
- Bundala is recognized as a Ramsar Wetland Site
- 41 wetland sites (of a total of the 83) are in the Asian Directory of Wetland Sites.

Fragmentation of the ecosystems is one of the major issues in biodiversity.

Plant diversity is high among the flowering plants. Over 480 flowering plant species are assigned threatened status. One of the highest agricultural diversities (Wijesinghe et at. 1993) in the island is found in rice with its 2,800 accessions and 7 wild relatives. The medicinal plants in the Island include about 1,414 species. Among them, 50 are heavily used, 208 commonly used, and 79 are threatened species (Anon 1996).

Over 30 species of ferns (Sledge 1981) and over 50 species of flowering plants (NARESA 1991) including 13 orchid species, are suspected to be extinct. Animal extinctions include the gaur and comb duck (Anon 1991) and possibly 13 species of snakes. Wild relatives of agricultural crop plants like those of rice are severely threatened due to loss of their habitats.

Pressure

High population density and expansion of the human environment increasingly threaten the Island,s biodiversity. Other pressures are:

- Sedimentation arising from soil erosion: Wetlands and marshes, which offer habitats for many indigenous and migratory birds are thereby threatened

- Filling of land for development: This has occurred mostly in urban areas in and around Colombo
- Threat from introduced species: The country has developed a few high-yielding varieties of rice following the Green Revolution. These have eliminated a large number of local varieties. Today the total paddy acreage is sown with less than six hybrid varieties.
- Encroachment: Many reserves have been encroached during the last few decades. Forest patches interspersed with settlements are more vulnerable to local pressure of encroachment. Chena cultivators clear new lands with the decline of productivity of the previously cultivated land.

The major environmental issue in built up areas is the management of solid waste. Air pollution and water pollution are also significant in urban areas.

Only 24% of the houses in Colombo are linked to the city sewerage system built in 1916. Some sewage is directly discharged into waterways. There are no sewerage management systems in other parts of the country.

Lack of safe drinking water is a serious issue in most urban areas. 75% of the towns in the Western Province are served with pipe borne water and others depend on surface wells. There are indications that wells in close proximity to latrines are contaminated.

Land Use in Colombo District

Land Use Category	% of Total	
	1981	1996
Urban Built up	12.2	19.6
Homestead	21.2	22.0
Trees and Other	41.2	35.1
Crop Land	16.4	16.9
Natural Forest	2.2	2.2
Scrub & Grass Land	1.8	1.6
Wetland	1.8	1.3
Water	3.3	3.3
Barren Land	0.3	

Source: UDA 1996

2.2.7 Built Environment

State

With the increase of population and efforts to increase the standard of living, the built environment has expanded significantly. Colombo and its suburbs have developed into a metropolitan area with a population of around 3 million. Most of the commercial and industrial establishments in the country are located in the Greater Colombo Area. The city of Colombo has an influx of a floating population of over 700,000 arriving in 307,000 vehicles. In addition, several provincial cities e.g. Kandy, Kurunegala, Galle too have expanded.

Colombo city, with an area of 75 square miles, (about 0.1% of the total land area) is highly built-up. Although there is a large tree cover in the district, it is fragmented and interspersed within the built up area.

Colombo does not have sanitary landfills and solid waste is open dumped in a few locations in the city. Poor waste collection and management and irresponsible behaviour of residents have led to solid waste being accumulated in many places. Similar problems are observed in other towns as well. In semi urban and rural areas, the problem of waste disposal is less severe.

The disposal of clinical waste causes serious concern. Apart from a few hospitals with incinerators, clinical waste is disposed along with domestic waste.

Another issue is the conflicting nature of landuse patterns. Most urban areas do not have land use zoning or zoning plans. Even where they have such plans, these are not effectively implemented. There are instances of industries located in residential areas (e.g. Ratmalana, Jaela) discharging toxic waste. Most cities still depend on a transport network that was designed and built in the 19th century. Although some improvements have taken place, transport development has not kept pace with increased demands.

Stream Polluted with Waste

Source: MASL File Photo

Pressure

The major pressures on built environment are:

- Inappropriate land use
- Inefficient public utility services (e.g. sewerage, roads, drinking water supply) to meet increasing demand
- Migration of rural population to urban centers and illegal settlements in environmentally sensitive areas
- High density of population
- Congested town centers
- High concentration and further expansion of industries in urban areas
- Reclamation of wetlands and open spaces

2.3. Linkages to Global Environment

2.3.1 Climate Change

Status

Sri Lanka, as a party to the United Nations Framework Convention on Climate Change ((UNFCCC), has addressed and prioritized climate change issues, even though the country,s contribution to the global greenhouse gas (GHG) emissions is insignificant. According to the National Greenhouse Gas Inventory for the year1994, Sri Lanka,s per capita carbon emission is about 0.4 tonnes.

The energy sector is a major contributor to greenhouse gas emissions. The transport sector consumes 99% of the petroleum energy and accounts for 54% of the total carbondiozide emissions of the energy sector.

Clean Development Mechanism (CDM)

An expert committee has been established to develop the national CDM strategy. Two CDM study centres are to be established in the Universities of Peradeniya and Moratuwa.

Pressure

The major pressures on climate change include

- Increased demand for energy at a rate of 10% per annum. Large-scale hydropower generation has reached the threshold level and thus the country has increasingly to rely on fossil fuel for power generation
- Increased number of vehicles
- GHG emissions from agricultural sector and animals
- Industrialization
- Deforestation

Environment ameliorating factors show a significant decline

Industrial Emissions

Source : Statistical Compendium of Environmental Statistics Department of Census and Statistics (1998)

National responses

- Sri Lanka ratified the UNFCCC in March 1999
- The first national communication was prepared and submitted to the UNFCCC Secretariat
- A National Action Plan on Climate Change and national GHG inventory have been prepared
- Studies are being conducted to develop a national strategy for CDM under the Kyoto Protocol
- Several studies have been undertaken to assess the feasibility of CDM

- Nation-wide awareness programmes on climate change and CDM are being conducted
- An AIJ (Activities Implemented Jointly) project in its pilot phase is being implemented to market Solar Home Systems (SHS) as an alternative to the use of kerosene lamps and diesel-powered lead-acid batteries. This endeavour by the Solar Electric Light Company (SELCO) will benefit rural homes without electricity

2.3.2. Ozone Depletion

State

The Montreal Protocol Unit (MPU), established in the MoFE, coordinates the implementation of activities of the Montreal Protocol on phasing out substances that deplete the ozone layer (ODS). Much success has been recorded.

The major ODS consumed is CFC 12 for refrigeration and air conditioning. CFC consumption has been considerably reduced through programmes conducted by MPU. CFC use was reduced from a base line annual average of 446.03 metric tons in 1995 to 216.42 metric tons at the end of 1999.

This reduction was achieved by refrigerator companies converting to non-CFC technologies and by implementing a programme of recovery and recycling of refrigerants. More than 1000 technicians have been trained to work with alternate refrigerants and retrofit refrigerators with non-CFC substances.

Pressure

- Smuggling of used refrigerators into the country
- The lower price of CFCs is a disincentive to the use of alternate refrigerants
- Facilities available in rural areas are inadequate for the recovery and recycling of refrigerants
- Scarcity of spare parts for recovery equipment
- The rejection of a project proposal forwarded to the Multilateral Fund for assisting activated carbon manufacturers to phase out carbon tetrachloride has slowed down progress in this area.

Response

- A policy decision has been taken to phase out all CFCs by 2005 prior to the Protocol target of 2010.
- A code for refrigerants have been laid down with a view to reducing imports
- The import of used refrigerators has been banned
- Technicians for retrofitting refrigerators have been trained in the use of alternate substances and the training of trainers has also been undertaken
- Islandwide awareness programmes for the general public, NGOs and school children are being conducted
- A programme to phase out methyl bromide in tea plantation is being implemented

2.3.3 International Obligations

Sri Lanka has entered into international environmental agreements, conventions, protocols and treaties. The country was represented at the 1972 Stockholm Conference on Human Environment, and at the 1992 Rio Earth Summit held in Brazil, and is dedicated to implement all relevant chapters in Agenda 21.The government has ratified a number of environment related international conventions. In order to implement these conventions, a separate Global Affairs Unit has been established in MoFE.

2.3.4 Policy, Legal and Institutional

Provision is made in Article 27(14) of the Constitution of Sri Lanka for the protection of the environment as follows: "The State shall protect, preserve and improve the environment for the benefit of the community". Section 28(f) emphasizes the need to "protect nature and preserve its riches". Successive governments have affirmed their commitment to the protection of the environment.

Under the 13th Amendment to the Constitution, "environment" is a concurrent subject - shared by both Government and the Provincial Councils. However, only the North Western Provincial Council has passed an environment statute to date, whereby a separate Environmental Authority has been established, superseding the functions of the Central Environmental Authority (CEA) within the Province.

The CEA was established in 1981 with the enactment of the National Environmental Act (NEA) of 1980. It is entrusted with the overall responsibility of protecting and managing the environment. Two important legal instruments created under the NEA were the "Environment Impact Assessment" (EIA) and "Environment Protection Licence"(EPL). All development projects classified as "prescribed projects" are required to obtain EIA clearance from the appropriate authority. The EPL process for industrial units has been decentralized and Local Authorities are empowered to issue licences to specified industries. Both these

processes have now been simplified to enable entrepreneurs to invest and continue with their ventures without administrative impediments.

A separate Ministry was established in 1990 to formulate policies, address and coordinate all matters relating to environmental management. The National Environment Action Plan (NEAP) is the basic guidance document on the management of the environment. MoFE regularly updates NEAP through a consultative process involving all relevant stakeholders. The plan recognizes emerging issues, and has evolved as a planning process for Sri Lanka,s environmental agenda. The current NEAP 1998-2001 is now under revision. It articulates a vision for the future and identifies policy and institutional gaps, and the needed sectoral and intersectoral coordinating mechanisms to pursue the path of sustainable development.

In addition, several other instruments relating to environment have been developed over the years. They include

- National Conservation Strategy - 1980
- Clean Air 1992 - 2000
- Coastal 1994 -2000
- Forestry Sector Master Plan - 1995
- Forestry Policy - 1994
- National Industrial Pollution Management Policy: A Framework for Analysis - 1998
- Refrigerant Management Plan - 2000
- Initial National Communication under the United Nations Framework Convention on Climate Change - 2000
- National Action Plan for Protection of Marine and Coastal Environment from Land Based Activities - 1999
- Bioidiversity Conservation in Sri Lanka: A Framework for Action - 1998
- National Industrial Pollution Management Policy Statement - 1996

The overall approach of the Government to environmental protection is a combination of policies and strategies. These include regulation, adjustment of macro economic policies, and establishment of a dialogue with the private sector in order to strike the right balance between economic development and environmental protection The provision of incentives to industry to adopt environment friendly technologies, the integration of environmental concerns into projects and programs, and adoption of the concept of the ' real value' of natural resources are important components of the overall environmental protection framework for the country.

Public and community participation in environmental management is increasingly promoted and adopted by the MoFE.

2.3.5 Coordinating Mechanism

The coordinating mechanism known as "Committee for the Integration of Environment and Development Policy" (CIEDP) co-chaired by the Secretaries of the Ministries of Finance and Planning and Forestry and Environment was established in 1996. This Committee is supported by sectoral environment committees known as "Committees on Environment and Policy Management" (CEPOMs). CEPOMs will cover the following subject areas:

- Biodiversity
- Land
- Water
- Energy and Climate Change
- Industry
- Coastal and Marine
- Urban and Built Environment
- Environmental Health

2.3.6 Education and Public Awareness

Sri Lanka has also realized the need for the involvement of communities in environmental management. Education and public awareness in environmental management are carried out by state, private and public sector agencies. Following are some of the main programs currently in place:

- Environment has been introduced as a module in school curricula from Grades 3 to 13
- Modules on Environmental Management have been incorporated into all social, physical and biological science degree programmes at the Universities of Peradeniya, Moratuwa, Colombo, Kelaniya, Sri Jayawardenapura, Rajarata and Ruhuna
- Universities e.g. Peradeniya and Colombo, offer Bachelors and Masters level degrees in Environmental Management, Natural Resources Management and in specialized fields within environment science
- The MoFE and the CEA conduct training programs on environment for the benefit of the public service and schools
- Most technical colleges will introduce environment as a required module in the near future

- All environmental NGOs are involved in education and public awareness programmes. These activities involve the community to a large extent
- The MoFE has initiated the following programmes:

  - Technician Training Program for AC Refrigerant technicians by the Montreal Protocol Unit
  - School Programme on Climate Change jointly with the Dept of Meteorology
  - Awareness programmes for schools and NGOs on ozone depletion
  - Publication of .ŒSobha,, a magazine on environment in all three languages i.e. Sinhala, Tamil and English
  - Establishing Environmental Brigades in schools
  - Environment, Education and Awareness Division of CEA also conducts awareness programmes for schools and NGOs
  - The private sector also has begun to pay greater attention to environment. Several large industries have set up their own environmental units to monitor the environmental quality of their processes.

Society has been sensitized over the years on the obligation of all parties to protect the environment. Pressure from a well-informed society is bound to have a strong influence on all potential polluting agents.

2.3.7 Technological

Environmental management technology is still in its infancy in Sri Lanka. The adoption of high technology is slow mostly due to its prohibitive costs. Some banks (e.g. National Development Bank) have introduced loan schemes to assist industries to acquire cleaner production technology. However, a renewed interest in traditional environmental management technology has occurred,and the universities along with the state agencies have begun extensive research in these areas. Some traditional technologies (Kandyan Home Gardens, Sloping Agricultural Land Technology Projects) have been adopted with improvements.

- A Plant Genetic Resource Centre has been set up to preserve traditional varieties of rice, highland and horticultural crops
- A programme for recovery and recycling of CFCs is underway
- Support to private sector industries has been provided to manufacture refrigerators with CFC free refrigerants
- Support for studies on Clean Development Mechanisms under Kyoto Protocol has been initiated

2.3.8 Priorities

The National Environmental Action Plan (NEAP) was the first attempt to study environmental concerns in perspective, to identify institutional mechanisms that address such issues, to provide a time frame for implementation of proposed programs, and to assess investment needs. The NEAP identified nine areas of priority. The current NEAP 1998-2001 analyses sector issues under the following categories on a wider perspective, within the macro economic framework of sustainable development:

a) Land
b) Water Resources
c) Biological Resources
d) Coastal and Marine Resources
e) Industry
f) Minerals
g) Energy
h) Built Environment
i) Environment and Health

A consultative process initiated by MoFE identified the following five key areas for in depth analysis in this State of Environment Report.

a) Land Degradation by Soil Erosion
b) Waste Disposal
c) Loss of Biodiversity
d) Inland Water Pollution
e) Depletion of Coastal Resources

This in no way implies that other environmental issues are less significant.

The five critical issues will be discussed in detail in the chapters that follow.

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Part III Priority Issues

PART THREE : KEY NATIONAL ENVIRONMENTAL ISSUES

3.1 LAND DEGRADATION

3.3.1 Introduction

Land degradation has been defined as "the temporary or permanent lowering of the productive capacity of land. It thus covers various forms of soil degradation, adverse human impacts on water resources, deforestation and lowering of the productive capacity of the rangelands" FAO/UNEP/UNDP Study on Land Degradation in South Asia 1992)

The Global Assessment of Degradation (GLASOD) and International Soil Research and Information Center (ISRIC) have identified six main causes for erosion and erosion by water by water erosion is recognised as the most serious and widespread phenomenon (FAO/UNEP/UNDP Study on Land Degradation in South Asia (1992). It occurs due to natural causes and is also human induced. Soil erosion is the combined effect of soil texture, intensity of rainfall, and steepness of slopes. High intensity of rainfall, which leads to flooding, is considered to be the main determining factor of the rate of erosion. These factors, when combined with inappropriate land use practices and poor, management intensifies erosion of the soil.

The process of soil erosion in Sri Lanka commenced in the 19th century with the expansion of human settlements and cultivation of upland rainfed crops. It was aggravated by the changes in land use patterns during the British administration when upper catchments of major rivers located in the central highlands were stripped of natural vegetation to make way for plantation agriculture such as coffee and tea. Land clearing continued even after independence primarily for the establishment of human settlements and for agriculture.

The issue of soil erosion was first raised as far back as 1873 by J.D. Hooker, Director of the Kew Gardens (Sri Lanka Report of the Committee on Soil Erosion, 1931).

Since then soil erosion has continued to be a cause of major concern and successive

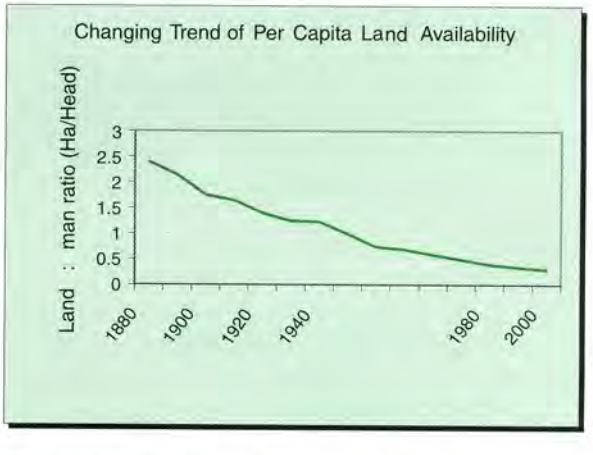
governments have taken a number of remedial measures, including enactment of laws and regulations.

According to FAO estimates of 1989, the extent of degraded arable land is about 10.8 %. (Report on Land Use- 1998) About 10% of the tea land and 25% of the rubber land have been abandoned due to reduced productivity caused by soil erosion (Griggs, 1988). The farming communities, as well as the policy planners, have not adequately appreciated the "real" cost of erosion to the economy because its adverse impacts are not immediately manifest.

3.1.2 Pressure

Several direct and indirect pressures contribute to soil erosion as given below:

- The total extent of agricultural land is 31% with a per capita land availability of .38 ha. Agricultural land per capita is .26 ha which is among the lowest in Asia (FAO/RAPA, 1992), and which is subjected to fragmentation and eventual overexploitation of land.
- Employment opportunities in the rural sector did not expand in proportion to increasing population. Consequently the poorer groups are forced to depend on the diminishing land resource base.
- Successive governments have therefore been compelled to create employment opportunities by alienating land.



Source : Statistical Compendium of Environmental Statistics Department of Census and Statistics

- With increasing demand for land, encroachment takes place in environmentally sensitive lands such as stream reservations. Encroachments are subsequently regularized at periodic intervals with the hope of freezing future encroachments. However, this expectation is seldom realized on account of the ground situation of landlessness and the continuing demand for land.
- Vulnerability to soil erosion is not adequately taken into account in alienating land.
- Unregulated and poor land use practices in cultivating these lands have resulted in widespread soil erosion.

The HARTI study reveals a relationship between poverty and extent of soil erosion

- Imperfect market conditions created by high taxes on imported potato have encouraged farmers to clear environmentally sensitive lands for cultivation of this high value crop. Such inconsistent macro economic and fiscal policies exert indirect pressures on natural resources. Many "chena" and "patana" lands have been converted to cultivation of erosive crops such as potatoes, tobacco and vegetables in view of better returns on investment.

Links between Erosion and Tenure

Land tenure	Highland avg. soil depth	Home Gardens avg. soil depth
Sole owner	4.40	3.34
Co owner	4.43	3.18
LDO*	5.27	3.53
Encroached (private)	5.00	5.33
Encroached (Govt.)	2.00	1.50
Leased in	4.1	-
Leased out	2.94	2.00
Rented in	4.00	-

* Allotments granted under the Land Development Ordinance

Source: HARTI -Socio -economic Survey 1998

- A survey conducted by Hector Kobbekaduwa Agrarian Research and Training Institute (HARTI) in 1998 established the relationship between soil erosion and insecurity of tenure. The topsoil was thinnest in encroachments on Government lands where the occupiers had no security of tenure. The HARTI survey also observed a direct relationship between poverty and the extent of soil erosion. The level of erosion was highest in the group whose annual income was less than Rs. 18,000. Agricultural holdings of less than .2 ha had the thinnest layer of topsoil.
- Annual leases by government and temporary leases granted by the private sector do not create the motivation required for the farmers to adopt soil conservation practices because the benefits of investment on land conservation are realised only in the long term. This applies also to leasing of agricultural land by entrepreneurs, very often on short-term basis, to cultivate commercial crops such as potato, vegetables and pineapples. The tenurial arrangements leave little incentives for the lessees to adopt conservation measures.

Soil erosion also takes place when land users have no incentive for investment in maintaining land productivity. Due to distortions in the land and credit markets, many landowners are encroachers, part time farmers or absentee landlords. Many of them have little incentive to invest in long-term land management. (NEAP-1998-2000)

- Smallholders grow tobacco on a wide scale, particularly on account of an attractive range of facilities offered by private entrepreneurs. The loss of soil on tobacco land is estimated at 70 mt /ha /yr. Krishnarajah, 1983 - Soil Conservation and Agricultural Aspects- ADB Report).
- The fluctuation of tea prices and high production costs over the last few decades have left little margin of profit for plantation management to invest on land improvement.

- Deforestation has caused the natural dense canopy forest cover in the country to dwindled from 80% at the turn of the century, to less than 24% by 1992. Forests have been cleared by government agencies for agriculture, settlement schemes and other development projects. They have been cleared illegally for shifting cultivation and for homesteads. Deforestation appears to be continuing despite efforts at controlling the problem and impacts adversely on the environment, the welfare of the rural sector, agriculture and related sectors and the overall economy of the country.
- The adverse impacts of "Chena" or "slash and burn farming" on the ecology and environment were highlighted in the Land Commission Report of 1987. They include changes in microclimate, soil erosion, and destruction of natural vegetative cycle and loss of forest reserves. With the diminishing land resource, "slash and burn" farming has been transformed into a system of " Unirrigated Highland Crop Farming" (UHCF) which is man's adaptation to nature as a strategy for survival (Tennekoon, M.U.A., 1993). Planting /sowing in UHCF systems is either with the "drought ending rain" or the soon thereafter, in mixed stands. This plant- crop mixture includes a variety of food crops, cash-cum -food crops, drought resistant as well as moisture loving crops of short and long durations of growth. The field research undertaken by Dr. M.U.A. Tennekoon has shown that UHCF farmers undertake such practices as construction of earth contour ridges, contour drains, terraces and retaining walls and growing hardy grasses on the contour of ridges. While conceding that some amount of erosion and environmental damage takes place, the study concludes that claims of environmental damage are somewhat exaggerated.
- Road construction and housing projects have contributed in no small measure to soil erosion. Sides of the newly constructed roads are rarely turfed and are thus exposed to erosion. Housing projects are sometimes located both by the government agencies as well as by private sector in erosion prone areas.
- Poor management practices are a major cause of erosion. It is seen that wherever sound agricultural practices such as enrichment of the soil by use of organic matter and mulching were adopted, the level of erosion had declined. Overgrazing has been a common phenomenon in areas with a high population of cattle and has contributed to soil erosion.

A lesser-known fact about farming in the hill country is that the farmers who have taken to cultivation of annual crops in slopy lands do not necessarily come from the poorer segments. Sometimes lands are leased by rich merchants for cultivation of annual crops and the tenant farmers become agricultural labourers.

3.1.3 State

Sri Lanka has a total land area of 6.5 million hectares of which approximately 96% comprise land and 4% water.

Soil Erosion by Regions

Location	Extent of soil loss - Tonees/ha/year
Hill Country	412
Mid Country	1,026
Low Country	147

Source: El Swaify (Hawaii) 1983

Soil Erosion Rates in Different Agro-ecological Regions

The extensive rates of soil erosion district wise ranges from 2.3% to 58%

Agro ecological Zone	Land Use	Soil Loss mt/ha/yr
Mid Country Wet Zone (Peradeniya)	Old seedling tea without conservation measures	40.00
	Well managed clonal (VP)tea on contour with lateral drains at 110m intervals	0.24
	Mixed home gardens with assortment of tree crops with heavy canopy	0.05
Hill Country wet zone (Talawakelle)	Clean weeded one year old clonal tea	52.60
	One year old clonal tea with mulch	.07
Mid Country Intermediate Zone (Hanguranketha)	Tobacco without conservation measures	70
	Capsicum without conservation measures	38
	Carrot without conservation measures	18
Low Country Dry Zone (Maha Illupallama)	Sorghum inter cropped with pigeon pea	21.00
	Sorghum/pigeon pea with 1500 kg/ha mulch	3.90
	Cotton under clean cultivation	22.00
	Cotton with mulch 3500 kg/ha	2.00

Source: Stocking M. (1992)

Estimated Extent of Land Subjected to Soil Erosion (as a percentage of total land area)

Soil loss is substantially reduced in well managed agriculture

District	% of land area
Colombo	2.3
Gampaha	2.4
Killinochchi	8.0
Kalutara	11.1
Mullativu	14.6
Mannar	17.1
Kegalle	17.3
Galle	20.6
Jaffna	22.7
Matara	24.4
Kurunegala	26.5
Vavuniya	28.2
Puttalam	28.6
Polonnaruwa	28.7
Batticaloa	30.9
Matale	38.1
Ampara	38.9
Kandy	41.0
Ratnapura	42
Moneragala	42.5
Hambantota	42.8
Badulla	54.8
Trincomalee	55.0
Nuwara Eliya	58.0

Source - N.B.Nayakekorala (1998)

Regional Patterns

A clear pattern of soil erosion has been observed in the Hill Country, mid country and the low country. Comparative studies of erosion by zones have shown that mid country to be the most vulnerable to erosion.

a) Hill Country

Soil erosion is of particular concern in the Hill Country where the watersheds of major rivers are located. The most important catchment i.e. the Upper Mahaweli Catchment (UMC) consists of 3118 sq. km.

The Mahaweli River feeds four major reservoirs viz. Kotmale, Victoria, Randenigala, and Rantembe and a diversion pond at Polgolla.

These reservoirs irrigate over 300, 000 ha of lands and generate 50% of hydropower. Hence erosion, largely gully erosion is a major concern in the Hill Country.

Typical land use changes in the hill country districts have a direct bearing on increasing soil erosion rates.

b) Mid country

Soil erosion appears to be acute in the mid country intermediate zone particularly on arable cropping land due to a combination of factors. These include the large extents of land under plantation crops, fragmentation of land due to increase in population, encroachment of sensitive lands and the existence of immature brown loam soils vulnerable to soil erosion. A large percentage of tWD neglected tea lands are concentrated in the mid country. A similar pattern of erosion has been observed in the upper watersheds of Uma Oya, Kirindi Oya, Walawe Ganga and Kalu Ganga located in the mid zone. Neglected tea lands with a cover of less than 40% and human settlements are prone to erosion. The cultivation of varied seasonal crops such as tobacco, potato, sugarcane, maize and vegetables on steep terrain with shallow soil is a contributory factor in erosion.

Mid country is most vulnerable to soil erosion

c) Low country

In the low country, many home gardens have been converted to the cultivation of commercial crops such as tea and pineapple resulting in soil erosion. Forestlands in the low country released for timber extraction develop large-scale gully formations.

Land use Changes in Kandy, Matale and Nuwara Eliya Districts- 1962-1982 (Acres)

Land use	1962	1982
Paddy	89839	96054
Other Field Crops	35787	59182
Tea	396567	320430
Perennial Crops	62918	87912
Wood and Forests	52947	32086
Pasture	7791	9254
Road/Buildings etc.	19004	34274
Waste lands	15430	23747

Source: Department of Census and Statistics, 1962 and 1982.

Soil Erosion rates under different Crops in Nuwara Eliya District

Tobacco	70 mt/ha/yr.
Capsicum	38 mt/ha/yr.
Carrots	18 mt./ha/yr

Source: Stocking (1992) and Bandaratilleke (1999)

Soil erosion under different crops

Tea

Soil erosion rates vary with different crops

The pressures on land leading to soil erosion also emanate from the commercial sector. It has been established that soil erosion is very high on abandoned and poorly managed tea lands. A study of soil erosion in tea lands in the upper catchment of Mahaweli revealed that an estimated loss was 115 mt/ha/yr. (Krishnarajah, 1982).

The impact of differences in management of perennial crops as well as annuals on soil erosion is illustrated by the Erosion Hazard Rating (EHR) on a scale of 0 to 40 for UMC (Stocking 1992). Accordingly, tea with less than 40% cover has an EHR of 32 while tea with over 80% cover has a EHR of 1. Similarly, vegetable cultivation on slopes without conservation has the highest EHR (40), while vegetable cultivation on bench terraces has a very low EHR (0.2). Similarly, tobacco on uplands presumably without conservation has a EHR of 40 while the same crop on paddy lands has a EHR of zero.

Poorly managed tea lands as well as abandoned tea lands lose sediments 15 times more than in a homestead, and 20 to 22 times more than in the wet zone forests (Wickramasinghe -1988). The findings of most studies relating to soil erosion on plantations reveal that erosion rates are high where the groundcover is low. The problem is aggravated when appropriate conservation practices are not followed particularly on steep and sloping lands. An analysis of the trends of land use in UMC in 35 years from 1956 to 1991 has shown that the area under tea has fallen dramatically. A large extent of abandoned tea lands in the UMC has been converted to forest plantations or new settlements (leading to an increase of home gardens), or has been abandoned to low intensity uses such as sparsely used annual croplands, grass or scrublands. (Roger White et al . 1995). Mid country lands are considered marginal for tea and with the decline in prices, tea cultivation is not viable.

Cultivated extents have increased at the expense of forest

Marginal tea lands are often alienated to the landless under village expansion schemes. Since productivity of these lands has declined, crop yields are poor and the lessees lack the capacity to invest in soil conservation measures. Construction of housing units on small fragmented lands also leads to further erosion.

Rubber

The total area of rubber is reported as being 198,500 ha representing 9% of the total cultivated area. The cultivation of rubber above an elevation of 1000 feet (300m) is no longer recommended owing to the likelihood of disease. Rubber is now primarily concentrated in Kegalle, Kalutara and Ratnapura districts in the lowland wet zone of the southwest, which accounts for 68% of the total extent.

Most rubber plantations are located on lands with an average slope of 15-20%. Erosion becomes higher with the increase in slope and inversely with the level of management. In well managed rubber estates the run off is below the accepted figure of 5 mt/ha/yr even on steep slopes. (Samarappuli, I.N. et al, 1998). Management practices such as planting of leguminous creepers between rows of young rubber plants have contributed towards improvement of physical properties of soil and reduced the runoff.

Some Estimates of Soil Erosion in Tea Land

During Replanting[1]	250 t/ha/yr
Weeded tea[2]	51.9 t/ha/yr
Mulched (during monsoon)[3]	0.7 t/ha/yr
Unmulched (during monsoon)[4]	40 t/ha/y
Well managed Tea[5]	330 kg/ha/yr
Poorly managed Tea[6]	20 t/ha/yr

Source

[1] *Hasselo and Sikurajapathi 1985*

[2] *Manipura 1972*

[3] *Manipura et.al*

[4] *Manipura et.at. 1993*

[5] *and* [6]*Krishnarajah*

Coconut

Soil erosion is not a major problem in coconut lands as most plantations are located in flat terrain. The soil is slightly disturbed when the intensity of rainfall is high and is averted by practices such as mulching.

Highland agricultural crops

The rate of erosion depends among others on the level of management. The assessed soil loss in the UMC in respect of vegetables and potatoes and tobacco cultivation is over 100 mt/ha/yr. (Upper Watershed Management Project - Final Report, 1997)

A recent study undertaken in micro catchments in the hill country indicated that some of the homegardens in nine out of the ten catchments were subject to soil erosion. In three micro catchments over 25% of the homegardens were severely eroded. (National Status Report on Land Degradation - Implementation of the Convention to combat Desertification in Sri Lanka - 2000)

Abandoned "Chena" Land

Source : MASL File Photo

3.1.4 Impacts

The rate of erosion depends on a range of factors and an accurate assessment of the impacts, classified as on site and off site, is difficult.

On Site Impacts

The on site effects include a decline in soil fertility and a reduction in soil depth. Only a few assessments have been made to date.

A study conducted on tea lands showed little difference in N.P.K. loss resulting from erosion on seedling and vegetatively propagated tea lands. (Basnayake, 1985)

Studies on land degradation and productivity of tea (Ananda Cumaraswamy and Ekanayaka, 1996) has shown that a loss of one centimeter of soil cover reduces production by 44 kg/ha/yr.

Studies on rubber (Samarappuli and Ekanayaka, 1996) have shown a decline in production of 174 kg/ha /yr.

Exposed Soil in Agricultural Farmlands

Source : MASL File Photo

Accurate estimates of the decline in yields due to erosion are difficult because such decline could be dependent on several interacting factors such as soil fertility, climate, incidence of disease and pests an degree of past erosion. Some estimates of on-site cost of soil erosion are given below:

Sedimentation in Mahaweli River

Source : MASL File Photo

Off Site Impacts

The off site impacts have greater economic and social implications. They include siltation of reservoirs, sedimentation of farmlands,

streams and rivers and downstream floods. Since the major irrigation and hydropower systems are fed by reservoirs, the economic costs of siltation and sedimentation can be very high.Sedimentation and siltation of these water bodies have significant on site and off site effects. The sediment yield study undertaken by NEDECO (1984) of the Netherlands at a point in Peradeniya showed that the Mahaweli River carries 0 .5 million tonnes of sediment per year.

50% reservoir capacity at Rantambe will be lost in 12 years if no protection measures are taken for sedimentation

Sedimentation rates of major reservoirs and soil erosion rate of selected catchments given below clearly show the magnitude of the problem.

Estimated Off Site Costs

Type of Loss	Value (Rs)
Productivity	3,259 ha/yr
Nutrients	5,068 ha/yr
Nutrients in UMC Watershed	953 million/yr

Source:: Somaratna, W.G. (1998)

Sedimentation Rates of Reservoirs and Tanks

Reservoir	Observation period	Rate per annum (% of the reservoir capacity)
Rantambe	1991-92	4.30%
Victoria	1985-92	0.08%
Polgolla	1976-82	2.80%
Selected tanks in Anuradhapura District	1983-93	2.40%

Source : Wallingford 1995

The low dry weather flow of rivers is attributed to soil erosion. Sediments also affect the water quality of waterways and disturb ecological systems dependent on freshwater.

Floods and landslides are indirect effects of soil erosion. A higher frequency of landslides during the last few decades was observed, some being man induced, according to the National Building Research Organization (NBRO-1990). A reconnaissance survey carried out in landslide prone areas has indicated that approximately 12,500 sq. miles are vulnerable. During the first six decades of the 20th century there were six landslides whilst seven severe landslides were recorded in the six year period 1983-1989.

Other off site effects of soil erosion includes damage to roadways, choking drainage systems with silt and consequent flooding leading to increased road maintenance costs. It has been estimated that cost of a damage to Hill Country roadways through the cultivation of adjacent slopes is equivalent to ten years' income derived from that cultivation. (Samarasingha, S.N.R.D.A.,1998).

According to estimates made by Clarke in 1994, the cost of erosion per acre, over a twenty-year period, ranged from Rs. 162,558 to Rs. 406,396 in terms of crop loss and

Rs. 342,775 to Rs. 457,033 in loss of resource value respectively. Off site costs by sedimentation of reservoirs have been calculated at Rs. 8 million per year including the loss of irrigation water, dredging expenses and reduced lifetime of turbines.

On site and off site costs were estimated to range from Rs. 3000 - Rs. 4000 million annually (Griggs, 1998). Another study estimated the annual loss due to erosion at Rs. 4900 million (Munasingha,1998).

Recent developments have helped the soil conservation effort. Tobacco cultivation, which was concentrated in the hilly slopy terrain, is gradually moving towards the flat terrain of the dry zone. Rubber cultivation has moved out of the Hill Country and is now confined to less slopy terrain. Long term leases to plantation management companies create incentives for the adoption of better management practices.

3.1.5 Response

The concern of the Government regarding this problem is reflected in policy initiatives taken, enactment of legislation, the formulation of plans and strategies and the establishment of institutions to contain soil erosion. The approach to soil conservation is evidenced in the policies spelt out for management of natural resources in the National Land Use Policy, Forestry Sector Master Plan (FSMP) and the Agricultural policy.

Legislation falls into two categories:

(a) environmental safeguards and mandates
(b) mitigatory legislation

Environmental safeguards have been incorporated in several Acts and Ordinances such as Land Development Ordinance (1935), State Lands Ordinance (1947) the Agrarian Services Act (1979), the Mahaweli Authority of Sri Lanka Act (1979) and the National Environment Act (1981). Some of the safeguards provided in legislation include mapping out state land for prevention of soil erosion, measures to prevent encroachments etc. A number of areas have been declared erodible areas under the provisions of the Soil Conservation Act, enabling their enforcement to a limited extent in plantations. A Soil Conservation Unit was established in the Department of Agriculture in 1951.

Subsequently it became a part of the Extension Division on the rationale that soil erosion can be prevented through awareness creation. At present, the subject comes within the purview of the Natural Resources Management Center (NRMC) of the Department of Agriculture. It lacks the required resources in terms of institutional strength and finances for effective implementation of the provisions of the Act.

The Soil Conservation Act enacted in 1951 provides for:

- The declaration of erodible areas
- Restrictions on landuse practices on private lands
- Acquisition of sensitive lands for conservation purposes
- Control and exploitation of forests and grass lands
- Providing assistance to owners of land in sensitive areas.

In view of the limited progress in arresting soil erosion, the Soil Conservation Act was amended in 1996 making provision for a Soil Conservation Board with representation of relevant government agencies and for the establishment of a Soil Conservation Fund. Powers under the Act have also been delegated to Divisional Secretaries. Regulations have been framed under the Act and several meaningful steps have been taken to translate these provisions into action.

The Land Commission Report of 1987 made landmark recommendations to control land degradation and soil erosion, but little effort had been made to implement some of its far-reaching recommendations.

The importance of soil conservation plans is reflected in the FSMP. The National Environment Action Plan (NEAP) (1990) and its updates of 1993 and 1998. Land degradation has been recognised as a key environmental issue requiring the serious attention of Government. The FSMP analyses the relationship between forest depletion and soil erosion. NEAP (1998-2001) specified certain activities with time targets to address the issue. Although all recommendations have not been addressed, these efforts provide a framework for land conservation projects and programmes.

A number of administrative interventions and initiatives such as tea, rubber, coconut and export crop subsidies, are being implemented by respective agencies. These schemes ensure that appropriate soil conservation measures are adopted.

The MoFE serves as the focal point for the U.N. Convention to Combat Desertification Several donor-funded projects have been undertaken primarily to address issues of land degradation in the critical watersheds in the country. Some of the projects include the Upper Mahaweli Catchment Project (GTZ), Upper

Watershed Management (ADB), and Watershed Protection in Selected Micro Catchments of Mahaweli (World Bank).

The other projects /programmes related to soil conservation are:

- Re-forestation and Watershed Management Project (1980)
- Community Forestry Project (1982)
- Land Use Policy Planning Project (1983)
- Upper Mahaweli Watershed Management Project (1987)
- Forest Land Use Mapping Project (1989)
- Landslide Hazard Mapping Project (1990)
- Shared Control Of Natural Resources Project ((1992)
- Optimal Land Use in Sri Lanka with particular application to Land Degradation in Plantation Industries (1994)
- Environmental Action I Project (1995)
- Upper Watershed Management Project (1997)
- Integrated Rural Development Programmes (1982-).

These projects and programmes generated new policies and concepts of soil conservation, including the value of public participation and co-management of natural resources with the community. The government is now aware that soil erosion cannot be contained through simple technological interventions and those larger socio- economic factors that impinge on soil erosion need to be addressed. Strong emphasis has been laid on new conservation measures and techniques developed both by the Department of Agriculture and private researchers such as "Conservation Farming" and "Sloping Agricultural Land Technology (SALT)".

Successful Practice of SALT

Source : MASL File Photo

The Tea Research Institute has conducted research on different aspects of erosion as well as on technologies designed to arrest erosion. A continuous dialogue has been initiated with private plantations to persuade them to adopt soil conservation techniques. The Ministry of Plantation Industries regularly monitors the soil conservation measures adopted by the plantation management.

Conservation programmes implemented by the MoFE in the Upper Mahaweli catchment as well as in micro catchments serve as field laboratories for research. They offer insights into economic and social dimensions of soil erosion. A number of institutional interventions have been made aimed at arresting soil erosion. They include:

a) The establishment of a CEPOM by MoFE to cover the subject of land, with particular emphasis on soil conservation, with representation from major stakeholders to coordinate related activities at senior management levels.
b) Establishment of the Land Use Policy Planning Division (LUPPD) in the Ministry of Lands, and a district network to implement conservation measures.
c) Establishment of a landslide unit in the NBRO.

3.1.6 Recommendations

The most desirable approach to soil conservation is summed up in the Sri Lanka/German Upper Mahaweli Watershed Project Review - 1993. It reads as follows:

"Land rehabilitation should be seen as an "investment" turning a national liability (degraded lands) into a national asset (environmentally stable lands). Rs. 250,000 per ha is the approximate value loss due to complete degradation. This could be halted by investing a fraction of this amount".

- The most important pre-requisite for the implementation of a soil conservation programme is the development of a sound land use policy for the country to provide the guidelines to the government, private sector and the community. A committee of officials has undertaken the initial work. The policy has now to be fully developed and adopted by all related agencies including sub national bodies
- Policies and strategies should be developed on the basis that population will stabilize at approximately 23 million by the year 2020 and

that urban migration patterns will leave 70% of the population in urban centers

- A policy of weaning rural people away from land based employment should be adopted by providing employment avenues in industry and service sectors in rural areas
- The practice of providing land in lieu of employment opportunities should be discouraged and environmentally sensitive lands protected. The importance of land zoning recognised by Government and Provincial Councils should be implemented
- The Government should gradually shift away from its role of "provider and implementer" to that of a "facilitator" in land management, and clearly defines future role, vis-a-vis sub national bodies. Local Authorities, particularly Pradeshiya Sabhas, need to play a pro-active role in soil conservation programs
- Emphasis should be paid to the 'real cost' and the opportunity cost of land as an economic commodity
- Traditional valuation systems should be reoriented to take into account the environmental externalities
- Fiscal planners should appreciate the causal linkages between macro economic policies / fiscal policies and soil erosion. Studies by Kotagama (1998) indicate that direct or hidden subsidies for erosive crops motivate people to cultivate erosion prone lands. The study also reveals that farmers in Nuwara Eliya and Welimada alternate between potatoes and beans, a less erosive crop, in response to adjustment of tariffs. Wilfred Cruz (World Bank, 1996) has shown that trade liberalization leading to higher prices of agricultural products will in turn motivate farmers to make higher investment on land
- Long-term leases provide incentives to adopt soil conservation measures as opposed to short-term leases
- Where critical watersheds fall within private lands (including plantations) legislation is required to regulate land use with particular reference to soil conservation. Given the current costs, small holders in critical watersheds are unable to make the investment required for soil conservation. Taking into account the economic advantages of conservation of environmentally sensitive areas, the payment of selective subsidies to farmers may be considered
- New institutional mechanisms involving farmer organizations and the community should be developed at grassroots levels. Community based participatory approaches should receive high priority in future programmes. Existing organizations such as the LUPPD, NRMC of the Department of Agriculture and the Tea Research Institute, already engaged in related activities should be strengthened by providing the required resources
- The Finance Commission may consider higher allocations to Provincial Councils in the hill country for required investments to protect land and water resources, which will benefit the entire country
- Technological interventions for soil conservation should be given high priority. Investments in research and development are necessary to develop and disseminate alternative techniques of soil conservation such as SALT, the use of vetiver grass etc
- The use of organic matter to build up humus to prevent erosion can be encouraged
- The Department of Agriculture should develop appropriate cropping systems incorporating ecological, social and economic goals for specific locations and landscapes. A centralized agency cannot administer a soil conservation programs from the center. Whilst laying down broad guidelines, implementation should be in the hands of appropriate sub national agencies
- The Natural Resource Management Center of the Department of Agriculture has a pivotal role in the promotion of soil conservation measures.
- Soil conservation units of Provincial Councils need to be strengthened
- New research programs emphasising adaptive research should be initiated in collaboration with local universities, and budgetary provision should be made for the research as well for dissemination of research findings. Farmers, plantation managements and the community should be closely involved in the exercise
- It is desirable to enhance the research capabilities and to equip the Department of Agriculture, relevant research institutions and universities by providing the required equipment and expertise to access information and join international networks for the sharing of information.
- Soil conservation programs should be developed to suit different agro climatic zones and not rely on a single model
- A major shortcoming in soil conservation programmes is the laxity in respect of enforcement. Strict enforcement of regulations is necessary with appropriate institutional mechanisms to obtain public collaboration
- Public awareness and education programmes targeted at school children can pay rich dividends. Greater emphasis should be paid to public

participation essential in the context of scattered and fragmented land holdings

- A Master Plan, incorporating these recommendations, should be developed

with the participation of all stakeholder agencies, adopting a transparent process

3.1.7. Gaps in Knowledge, Data and Information

The absence of a central database and a body of knowledge and information point to the severity of the problem.

- Soil related data are primarily used for research Provincial Councils databases on natural resources should incorporate information on Soil.

- Time series data that relates to soil erosion in the same location are rarely available, making meaningful analysis difficult. Disaggregated data by micro agro climatic zones, and records of shifting cultivation are not available
- Information on soil erosion is collected by different agencies for specificpurposes and is not focused for the benefit of the decision-makers. Data is also not converted into "information" and made readily available to thestakeholders

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3.2 WASTE DISPOSAL

3.2.1 Introduction

Management of waste, both liquid and solid, has become a critical environmental concern particularly in the more urbanised areas of Sri Lanka. With changing consumption patterns, the quantity of solid waste has increased over the years. Rapid economic changes resulting from the introduction of more liberal, industrial and expansive growth policies during the last two decades have not been balanced by necessary investments in urban infrastructure facilities, particularly in the areas of urban solid waste management.

Rural waste generation, apart from being small, is largely biodegradable

a higher amount of non-biodegradable components than in rural areas. Ever growing quantities of solid waste impose increasing pressures on individual Local Authorities (LAs) who are responsible for the management of waste.

Local Authorities are responsible for the collection and disposal of solid waste arising from the following sources:

- residential and commercial (including market waste)
- hospital waste (clinical and non-clinical)
- industrial waste
- slaughter house waste
- drain clearings and street sweepings

Waste Generation Rates

Local Authority	No[a]	Per capita waste generation[b] (kg/per day)
Municipal Council	12	0.65 - 0.85
Urban Councils	37	0.45 - 0.65
Pradeshiya Sabhas	255	0.20 - 0.45

Sources: (a) MoFE (1999) and (b) adapted from ERM Data(1997)

Urban areas are often littered with garbage as a consequence. Finding suitable land for disposal or central waste treatment / management facilities in the urban areas has become difficult. The problem is most severe in the densely populated areas of the Western Province. In rural areas due to lower population densities and greater availability of land, disposal of solid waste is not as serious an issue.

In order to address the need for a sustainable integrated solid waste management system/s in the Island, the MoFE has developed a National Strategy for Solid Waste Management in collaboration with relevant stakeholders.

3.2.2 Pressure

The current population in Sri Lanka is close to 19 million of which 72 % is rural (Central Bank, 2000). Waste generation is low in rural areas and the little waste generated is mainly biodegradable. In most rural areas, management of solid waste is undertaken at individual or community level and is within the carrying capacity of the local environment.

Irrespective of the source, organic matter comprises the large portion of waste

By contrast, the urban areas are densely populated and generate larger quantities of waste, which contain

Water and waste water treatment plants generate sludge that requires safe disposal. However, the lack of facilities and sites for safe disposal of treatment plant sludge results in haphazard dumping, leaving the problem only partly solved. In addition septage generated from the dislodging of septic tanks too are part of the solid waste stream .Little information is available on sources and quantities of sludge.

3.2.2.1 Municipal Waste

The data available that would help estimate the total quantity of municipal waste collected or generated in the country is not entirely accurate. However, the best estimate of total waste generation in Sri Lanka is around 6,400 tonnes per day. Waste generation rates are based on MOFE data on Municipal waste and on data on Colombo Environmental Improvement Program obtained by ERM. Discrepancies arise on account of lack of measurement of waste collected. Weighing facilities are available only in the Colombo Municipal Council (CMC).

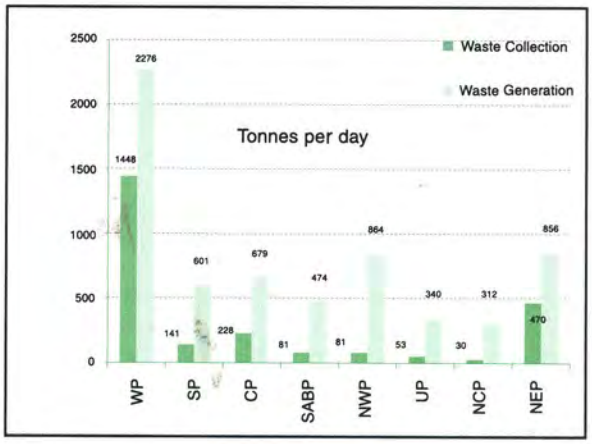
Daily waste collection by Local Authorities is estimated at 2,500 tonnes (MoFE). Of the total waste collected, the Western Province accounts for 57 percent.

Overall, there is significantly low-level collection service coverage in Urban Councils and Pradeshiya Sabhas. The fundamental problem faced by the LAs in providing adequate service coverage is the lack of resources, primarily in respect of suitable collection vehicles, adequacy of finances and shortage of manpower.

Waste from residential and commercial sources is mainly organic in nature. Municipal waste collected from domestic and commercial sources also includes small quantities of hazardous waste, such as lead batteries.

The waste generated from industrial and hospital premises comprises hazardous and non-hazardous materials. Precise quantities and characteristics of hazardous waste are not available. However, in a preliminary survey carried out on 34 industries by Environmental Resources Management in 1996, the following hazardous wastes were identified.

Generation and Collection of Municipal Solid Waste Quantities by Province -1998



Source: MoFE Data (1999)

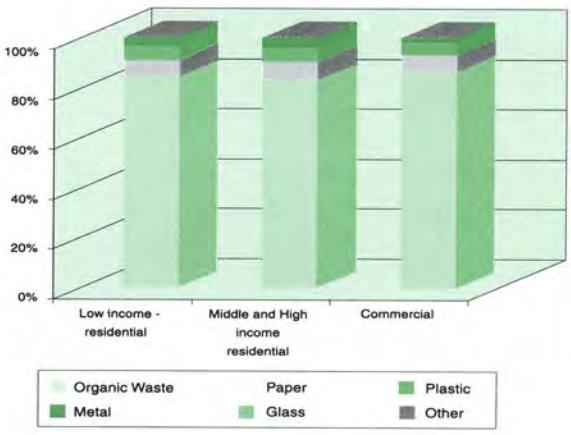
The gap between generation and collection of MSW indicates the gravity of the problem

Local Authorities with a Waste Collection of more than 50/tonnes/day

Local Authority	Quantity of Waste Collected (tonnes/day)
Colombo Municipal Council	680
Dehiwela-Mt. Lavinia MC	150
Moratuwa MC	135
Bandarawala UC	118
Kandy MC	102
Sri Jayawardenapura-Kotte MC	95
Trincomalee UC	72
Kayts PS	60
Negombo MC	54

Source : MoFE Data (1997)

Municipal Solid Waste Composition



Hazardous waste has the least amount of biodegradable material

3.2.2.2 Hazardous Waste

- **Inorganic Wastes** - inorganic acids, inorganic alkalis, zinc bearing wastes, heavy metal wastes, and waste treatment sludge;
- **Organic Wastes** - oil wastes, including those derived from motor vehicles, solvent wastes, waste paints, lacquers, varnish, agro chemicals,
- pharmaceuticals, wood preservative, PCB (polychlorinated biphenyl),PBB (polybrominated biphenyl), and PCT (polychlorinated thianthranes); and
- **Other wastes** - asbestos wastes, plastic/resin wastes.

Hazardous Waste Generation Rates

Growth Scenario	Hazardous Waste Generated (tonnes per annum)
Zero growth	41,819
Seven and half percent growth	53,500
Fifteen percent growth	74,635

Source: ERM Data (1996)

Composition of Hazardous Waste (Based on total annual generation for 1996)

Source : ERM Data (1996)

Hazardous waste (excluding clinical waste) was estimated at 40,617 tonnes in 1996. The distribution of the waste types according to the above classification is represented diagrammatically below.

On the basis of three different growth rates (from 1996) for industrial hazardous waste, the estimated annual generation rates for the year 2000 are given in below.

Around 50 percent of the hospital waste consists of clinical waste which includes:

- human tissue, sharps, pathology and laboratory wastes
- pharmaceutical wastes
- disposable equipment and containers that have been in contact with body fluids
- special treatment waste such as cytotoxic wastes related to chemotherapy
- low level radioactive wastes

Even at zero growth, hazardous waste generation is substantial

Although data is not available for clinical waste generated in Sri Lanka, a survey limited to Colombo estimated a total waste generation of 3 tonnes per day in 1996. (ERM, 1997, b &1997,c)

3.2.2.3 Waste Projections

Municipal Waste

The past two decades has seen a marked increase in industrialisation in rural areas. The Government's policy to improve access to, and in, rural areas through infrastructure development and targeted regional growth centres (e.g. Seethawaka Industrial Estate), will have a strong influence on the quantities and composition of waste generated in areas that are currently predominantly rural. As a consequence, the problems of solid waste management now experienced in urban areas will become more widespread across the Island.

Projections for waste collection quantities have been carried out for the years 2001 to 2010. The projections are based on current waste collection rates (not generation rates) and a population growth rate of 1.2 percent. The projected waste collection quantities for the years 2000, 2005 and 2010 are summarised below.

The estimates given above are only an indication of the approximate waste quantities that will be collected in the future and would require final disposal.

Hazardous Waste

Hazardous waste is also expected to increase substantially over the next decade. At a conservative growth rate of 5 percent per annum, the hazardous waste generated in year 2010 is estimated at 80,420 tones.

Projections for Quantity of Waste Collection

Year	Projected Quantity Of Waste Collected (tonnes per day)
2000	2,560
2005	2,720
2010	2,885

Source ERM (1996)

3.2.3 State

3.2.3.1 Disposal of Municipal Solid Waste

The prevalent method of disposal of solid waste in Sri Lanka is open dumping. This comprises non-engineered sites where waste is tipped haphazardly without environmental controls. A majority of open dumps are in low lying areas such as marshes and abandoned paddy fields infilled with solid waste primarily as a means of land reclamation. A review of dumpsites of the Greater Colombo Area (GCA) was carried out under the Colombo Environmental Improvement Project in 1999/2000. It was found that the 41 existing disposal sites in the GCA were all open dumps with the exception of one site where market waste was buried in trenches.

In the same study it were reported that more than 60 percent of the sites was on privately owned lands with the remainder being state lands. Private lands are released as dump sites largely for reclamation of the land for purposes of building construction. Most of the disposal sites in the GCA are small in extent, with around 70 percent being less than 1 ha. 46 percent of the sites have a remaining life time of less than 3 years(ERM 2000a) Due to various factors such as urban sprawl and severe public opposition to the siting of such facilities (Not In My Back Yard - NIMBY syndrome), finding disposal sites in urban areas is increasingly difficult. Few sites in the urban areas have the capacity to receive waste for more than six months, and thus are transient. This indicates the severity of the crisis in the disposal of waste.

None of the open dumpsites are engineered to minimise or control pollutants released from the decomposition of waste. Waste is disposed of at the site and it appears that due to high costs involved, there exist little or no basic operations such as levelling and covering of waste. Most often, soil cover is applied only at the final stage if and when there is a projected use for the land, or due to public pressure. It is reported that the Kandy Municipal Council is in the process of providing some form of leachate treatment, by intercepting the leachate, treating it in a series of ponds and recirculating the leachate in its dumpsite of a total area of 31 acres.

Although this site has been used since the 1960s, the leachate treatment process is of recent origin and has not been subjected to an evaluation.
In addition to dumpsites operated by the relevant authorities, haphazard dumping takes place along streets, marshes and abandoned paddy fields by private individuals. LAs with regulatory responsibility exercise little control over these practices mainly owing to a lack of resources.

3.2.3.2 Disposal of Hazardous Waste

In the absence of a secure disposal facility, hazardous industrial waste is generally stored on site without adequate management. Alternatively, some industries dispose of their hazardous waste together with other municipal waste, or just dump the waste on vacant land.Some industries sell the waste for re-use. For example, waste oil is sold for treating timber and as a fuel for burners. In some instances, industrial waste is bought merely to recover the container, resulting in the waste being disposed of in an indiscriminate manner by the purchaser.

A majority of the hospitals dispose of sharps by burning them either in a pit or on open ground within the hospital premises. A few hospitals are equipped with incinerators where all clinical waste is burnt. Body tissues, remains from amputations etc., are generally buried by the hospital authorities, by undertakers or by LAs. Placenta is sold to private vendors. These methods are generally adopted in hospitals where segregation of clinical and non-clinical waste takes place. Where segregation does not take place, sharps and the rest of the clinical waste are mixed in the municipal waste stream.

In 1996, over 95 %of the clinical waste generated in Colombo was disposed of in open dumps with no form of pre-treatment (ERM, 1997b, 1997c).

Due to non-availability of a clinical waste disposal system, even clinical waste segregated at source is mixed with the non-clinical waste during transport and eventually reaches the open dumps. This is a health hazard especially to those coming in contact with the waste. It could be concluded that the current disposal sites receive all types of waste including clinical and hazardous waste.

The MoFE has identified a few sites for hazardous waste disposal and is currently carrying out environmental and technical feasibility assessments to determine the most suitable site/s.

Open Dump Site in Atthidiya Marsh

Source: ERM File Photo (1997).

3.2.4 Impact

3.2.4.1 Impacts on Land

- **Reduction in flood retention areas** due to a majority of disposal sites being located in low-lying areas such as marshy lands and abandoned paddy lands
- **Reduction and pollution of wetland habitats** in sites such as Attidiya and Muthurajawela marshes
- **Aesthetic impairment** due to wind blown litter and waste left uncovered during and after cessation of operations
- **Degradation of land** due to leachate seepage from uncontrolled dumping with adverse effects on soil fertility and productivity.
- **Differential settlement** in sites that are reclaimed for future development. With the decomposition of Municipal Solid Waste (MSW), settling is unpredictable with a possible risk of structural instability and collapse.

3.2.4.2 Impacts on Water Resources

- **Pollution of groundwater and surface water:** In the absence of engineering methods to treat leachate generated from decomposing garbage, it enters groundwater and surface waters. The BOD (bio-chemical oxygen demand) of the leachate ranges from 2,000 - 30,000 mg/l (Tchobanoglous, et.al 1993). The Central Environmental Authority lays down that waste water discharged to surface waters be treated to reduce BOD concentrations to no more than 30 mg/l. This gives an indication of the level of pollution generated by leachate entering water courses.

Open Dumping into Waterways

Source : MASL File Photo

This is particularly significant in areas where groundwater is the only source of potable water. The impact of ground water contamination is generally irreversible. It is reported that the National Water Supply and

Drainage Board (NWSDB) had considered the option of using groundwater to increase the supply of potable water to residents in the Greater Colombo area. However, due to the pollution of the ground water aquifers in the region, primarily caused by open dumping, the NWSDB was not able to proceed with this option. With Japanese funding amounting to Rs. 8.3 billion, the NWSDB has now initiated a project to tap the Kalu Ganga (south of Colombo) as a source for the Greater Colombo Area.

Many Local Authorities dump MSW into rivers and streams with consequent contamination of potable water supply downstream. The Kelani River, which is the present source of potable water for the GCA, is polluted by leachate from a number of dumpsites along the banks of the river.

In instances where clinical waste is co-disposed of with other waste, there is a possibility of pathogenic organisms entering water courses, resulting in health risks to water users.

3.2.4.3 Impacts on Biodiversity

- Changes in the ecological balance of the surrounding area due to attraction of vermin and scavenging animals, and the effects of contamination of water bodies from leachate and solid waste e.g. the Attidiya marshes.

3.2.4.4 Impacts on Air Quality

- Mmalordorous environment due to anaerobic decomposition of underlying waste and generation of methane, which contributes to greenhouse gas emissions.

3.2.4.5 Impacts on Health

- Insect/mosquito breeding in stagnant water pools on waste sites and in canals and waterways blocked or constricted with waste resulting in the spread of disease
- Health hazards to workers and neighbouring residents: There are significant health risks due to the existence of vermin, insects, flies and scavenging animals particularly to workers on site and waste pickers. They are exposed to health hazards primarily by coming into contact with syringes, contaminated needles, other hospital wastes, faecal matter and hazardous wastes. Partly burnt organic compounds could also result in serious health problems.
- Nuisance caused to the neighborhood due to odour, flies and constant movement of refuse transporting vehicles delivering waste to the site
- Hazards associated with collapse of slopes where MSW is dumped in an uncontrolled manner with side slopes not maintained at IV: 3H. The structural failure of slopes can cause property damage and injury or loss of life.

Open Dumping of Garbage in a Protected Bird Sanctuary

A court order was issued against the Central Environmental Authority (CEA) and the Dehiwala - Mt Lavinia Municipal Council (DMMC) to stop open dumping of waste in the protected Bellanwila-Attidiya Bird Sanctuary, on the initiative of a leading environmental NGO. Since July 1999 DMMC has been using marsh land immediately south of the bird sanctuary whilst seeking an alternative site. This location too has attracted public opposition, and a second court case is pending.

The 372 acre Bellanwilla Attidiya marsh land is home to a number of different species of

birds, butterflie,s reptiles, mammals and fish. This is also an important spot for migrant birds. In an international wetland survey carried out in 1980 by the International Union for the Conservation of Nature (IUCN) this marsh was identified as one of the 41 important wetlands in Sri Lanka, and recognised as an important marsh in the Asian region.

The population in the DMMC area is estimated at 250,000, and the daily waste collected is around 125 tonnes. In the absence of any alternative site within their municipal limits, the Local Authority was forced to dump the waste in the adjoining marshland. The LA officials are faced with a no win situation. They are aware of the serious environmental damage that is being caused by the use of this site, but ask, " What is the alternative?" If waste is not collected, the tax paying residents complain, but once collected, the LA is unable to dispose of it.

3.2.5 Response

3.2.5.1 Waste Treatment

Some LAs have initiated various treatment technologies for part of the waste stream with a view to resource recovery and reduction of waste quantity requiring final disposal. Composting and anaerobic digestion are treatment methods that have been tested, on a pilot scale, for biodegradable components of the waste.

3.2.5.2 Composting

Composting of wastes at household level has been piloted in many LAs by the introduction of composting barrels/bins provided either by the LAs or NGOs.

Centralised composting projects have been initiated in a few Local Authorities. The success of such efforts has been limited owing to poor location e.g. proximity to a water body or housing leading to public protests over malodour and contamination of water bodies. The method widely used is windrow composting. Other methods such as in- vessel are also being tested.The following table summarises the present efforts at composting Municipal Solid Waste

As indicated above, the GCA has only one centralised composting project (Kesbewa PS). It is estimated that only about 0.2% of the current waste collected in the GCA is composted.

Regular monitoring of these schemes which generally deal with market waste only and not mixed municipal waste, is not undertaken. Reports indicate that, other than at household level, there appears to be limited success in composting organic waste on a larger scale due to the following reasons:

- the inconsistency of the feedstock used even with market waste as the source, owing to the existence of small quantities of plastics and other low or non biodegradable constituents such as coconut husks and banana stalks, results in a poor final quality compost.
- inability to market the compost owing to public attitudes and the unpredictable nature of the feedstock which results in a product of variable composition. It is reported that the Kandy MC abandoned a vermiculture composting project for market waste as the product was of poor quality
- public opposition to siting any facility owing to odour from the facility e.g. the Panadura UC had to abandon its composting project due to public protests

3.2.5.3 Anaerobic Digestion (AD)

AD too is being tested as a means of waste management, with the dual aim of energy recovery in the form of methane generation and the production of a digested organic residue that could be marketed as compost. The National Engineering Research and Development Centre of Sri Lanka (NERD) has developed a dry batch reactor system, using source-separated green and market waste as feedstock. A pilot project has been initiated in Kirulapone. The primary aim of AD is energy recovery. However, in this trial project, the gas generation has been insufficient and trials are being conducted using only water hyacinths to compare the quantities of gas generated. It is unlikely that this method would be widely adopted.

The reactor, once in a batch system, cannot be used again until the digestion cycle is complete. A number of reactors would therefore be required to treat larger quantities of waste and is therefore not a viable proposition. The limited success of this technology is also due to management failures and a lack of commitment on the part of the community.

Compost Projects based on the use of Municipal Solid Waste

Local Authority	Current	Feedstock
Colombo MC[1]	150 compost bins	Kitchen/green waste
Dehiwala - Mt.Lavinia MC[1]	150 compost bins	Kitchen/green waste
Moratuwa MC[1]	1500 barrels	Kitchen/green waste
Kolonnawa UC[1]	20 barrels	Kitchen/green waste
Ja-ela UC[1]	18 barrels	Kitchen/green waste
Wattala UC[1]	30 barrels	Kitchen/green waste
Maharagama PS[1]	2300 barrels	Kitchen/green waste
Kesbewa PS[1]	Centralised plant run by a NGO	Market waste, animal dung and coir fibre
Mahara PS[1]	15 barrels	Kitchen/green waste
Matale MC[2]	Centralised plant	Market waste
Ratnapura MC[2]	-	Market waste
Balangoda UC[2]	-	Market Waste
Dambulla PS	-	Market waste

Source: [1] *Strategic Overview of Potential Solutions to the Crisis of Disposal of MSW in the Local Authorities of the GCA, Western Province Sri Lanka, 1999*

[2] *Newspaper reports*

3.2.5.4 Recycling and Resource Recovery

Recycling of materials is carried out through an informal market driven system. Items are recovered at various points of the waste stream: at household level, collection and transport by LA workers or at the final disposal site by rag pickers and municipal workers. The retrieved materials are sold to collection shops where they are cleaned and sold for recycling by local industrialists or exported overseas. The following materials are recycled:

- **Glass** (soda lime only, not sheet glass): The Ceylon Glass Company recycles the white and amber cullet whereas green cullet is recycled on small scale by private glass manufacturers.
- **Ferrous and non-ferrous metal** - recycled locally and exported in bales, after sorting and cleaning. The price of scrap metals is high due to the export demand.

Experience of Recycling in Maharagama

The Maharagama PS, encouraged by the MoFE, initiated a source segregation scheme among 2300 householders for separation of paper and cardboard, glass, metals and plastic, and polythene. It has appeared to be effective in reducing the total quantity of waste collected for final disposal in the short time that it has been in place. The Ministry, in an attempt to replicate this success story in other LAs has distributed a newsletter among other LAs giving guidance and encouragement to initiate such recycling practices.

- **Waste paper and cardboard** - recycled locally. The Vallachchanai paper factory of the National Paper Corporation runs wholly on recycled paper. A small quantity of corrugated cardboard is exported after shredding and baling. Newspapers cannot be recycled in the absence of de-inking facilities in the country. Newspapers are re-used mainly as a packaging material

- **Plastic** - HDPE (high density polyethylene), LDPE (Low density polyethylene), PET (polyethylene terephthalate) and PP (polypropylene) are recycled locally. However, the demand for plastic waste is seasonal as it dependent on the international price of the virgin material. The high cost of collection of clean plastic reduces demand. Research is being carried out by various individuals and organizations on fuel recovery from plastics and production of items such as fence posts using unclean plastics.

Some Local Authorities, through the intervention of NGOs, have established collection points where residents are requested to bring recyclable materials for purchase. However, this method has not proved to be effective owing to a lack of public response. Low-income groups extend their co-operation to these activities more readily than high income groups.

3.2.5.5 Incineration

The term "incineration" is broadly used in Sri Lanka if the waste is burnt in any form of enclosure. Incinerators are operated in a few hospitals and industries. The technology ranges from elementary to more advanced levels of operation. Incinerators in use have no emission control devices.

The LAs do not incinerate waste. It is unlikely that incineration would be adopted as a means of treating municipal waste, as the waste is mainly organic in nature, has a high moisture content and a low calorific value. It is estimated that the calorific value is around 4,000 - 5,000 kJ/kg (ERM 2000a). In developed countries where incineration is widely used, the typical calorific value is generally more than 9,000 kJ/kg. If incineration is to be adopted in Sri Lanka, there will be a need for supplementary fuel.

All treatment methods discussed above give rise to a residual waste, which needs disposal in an environmentally acceptable manner such as sanitary/ semi-engineered landfills. Whilst implementation of these treatment technologies should be encouraged, it should be noted that these methods are a means of reducing waste quantities requiring final disposal and do not eliminate the need for final waste disposal.

3.2.5.6 Institutional and Legal Framework

Waste management responsibilities in Local Authorities are generally assigned to the Public Health Department under the supervision of the Chief Public Health Inspector (CPHI) or Public Health Inspector (PHI). A few Municipal Councils have established SWM departments to perform duties of waste collection, treatment and disposal. The CPHIs and PHIs are responsible for many aspects of public health and sanitation beside SWM and consequently SWM is not generally afforded adequate priority.

The legal and regulatory framework relating to municipal solid waste and hazardous waste disposal is set out both at national and local government level. The main legislative enactment and regulations that deal with the issue of waste disposal are:

- The National Environmental Act
- Provincial Councils Act
- Local Government Ordinances
- Hazardous Waste Regulations

At the national level, the 13th Amendment to the Constitution (1987) which decentralises power to the provinces, and the Provincial Councils Act, No. 42 of 1987 contain provisions for waste management.

The environmental regulations are laid out in the National Environmental Act No. 47 of 1980 (NEA), as amended by Act No. 56 of 1988. Under Section 12 of the NEA, "the Central Environmental Authority (CEA), may with the concurrence of the Minister, from time to time, give to any Local Authority in writing such directions, whether special or general, to do or cause to be done any act or thing which the Authority deems necessary for safeguarding and protecting the environment within the local limits of such Local Authority".

The Environmental Impact Assessment Regulations (Gazette Extraordinary No. 772/22 of 24th June 1993, and Gazette Extraordinary No. 859/14 of 23rd February 1995) states that the development of any waste disposal facility with a capacity exceeding 100 tonnes per day is considered to be a prescribed project. In such instance, the developer should obtain an environmental clearance and should conduct an Environmental Impact Assessment (EIA), or Initial Environmental Examination (IEE).

The legal framework for waste management at the local government level comes within the Local Government Ordinances - the Municipal Councils Ordinance of 1980, the Urban Councils Ordinance and the Pradeshiya Sabha Act No. 15 of 1987. These Ordinances and Acts state that all refuse collected by the Municipal Council, Urban Council and Pradeshiya Sabha shall be the property of the Council

Under the Municipal and Urban Council Ordinances and the Pradeshiya Sabha Act, LAs have the power to make by-laws necessary for the control and regulation of industrial waste and to impose a penalty for the disposal of such materials.

Regulations for the management and control of hazardous wastes are published in the Gazette Extraordinary, No. 924/13 of May 23, 1996, in the form of an amendment to the National Environmental (Protection and Quality) Regulation, No. 1 of 1990. Schedule I in the regulations gives the waste types considered as hazardous waste in Sri Lanka.

Sri Lanka as a signatory to the Basel Convention has developed regulations and guidelines for reduction of hazardous waste, its disposal and control of trans-boundary movement. MoFE is currently carrying out training programmes for enforcement authorities e.g. Customs Department. The Ministry has drafted a National Strategy for Waste Management, which will be followed by the drafting of national regulations on waste management and disposal. Whilst the CEA will be responsible for overall management of the strategy, LAs will continue to play a lead role in implementation. MoFE has also prepared an Implementation Plan and an Investment Plan for seeking funds for the Strategy.

The Western Provincial Council has passed a Statute for the setting up of a Solid Waste Management Authority for the Province. Although, this has received the assent of the Governor, it has not been established as yet.

The establishment of a "Cleaner Production Center" has been finalised. The Norwegian Government has provided funds, and the Center aims to promote awareness and develop capacities for preparation and promotion of cleaner production techniques, incorporating waste minimisation technology and provide training and awareness among industrialists. The Center will also develop policy initiatives and conduct policy dialogues with stakeholders.

As in many other developing countries, waste disposal has been given relatively low priority. As a result, the enforcement of laws is weak. One of the fundamental problems in SWM is the lack of proper waste disposal facilities. For example, although all LAs that operate sites receiving more than 100 tonnes of waste per day should obtain environmental clearance, none of them have done so. The CEA does not and is unable to enforce the regulation and prohibit the use of such sites, as there are no alternative systems in place. Without proper waste disposal facilities, regulations pertaining to waste cannot be enforced and the objectives of legislation cannot be accomplished.

Furthermore, some of the clauses related to SWM in the Municipal Councils, Urban Councils and Pradeshiya Sabha Ordinances are outdated and need to be revised. Legally the LAs are limited to working within their local authority boundaries. As such, particularly in urban areas, where land is a limiting

factor in finding suitable disposal sites, the LAs are unable to share facilities with other local authorities. Current laws and regulations need to be amended to introduce an integrated approach to solid waste management.

3.2.5.7 Policies and Programmes

National Waste Management Strategy MoFE has developed a National Waste Management Strategy in which a 3 year action plan has been identified. The strategy emphasizes the need for waste segregation at source, waste avoidance/reduction, reuse and recycling.

- **Privatisation of Waste Collection**
  Over the past 2 years a few LAs have privatised waste collection services. A marked improvement in the street cleansing and door-to-door waste collection is evident. The smaller LAs view privatisation as a means to increase the coverage area and collection efficiency. With the move towards privatisation of waste collection it is anticipated that the waste quantities requiring disposal will also increase rapidly.
- **Privatisation of Waste Disposal**
  Some LAs, including Colombo Dehiwela- Mount Lavinia and Kandy Municipal Councils have opted to privatise waste disposal to overcome problems faced in finding disposal sites. However, there are instances where such arrangements have been unsuccessful. Wattala Pradesiya has privatised collection and disposal for part of the waste stream. The contracted party, which was expected to find a site to dispose the waste in an environmentally sound manner, continued the practice of open dumping. This may be due to flaws in the conditions of enforcement.
- **Donor funded Programmes**
  Financial constraints being the primary cause for lack of proper solid waste management, donor agencies have initiated a number of projects:

  - World Bank funded Colombo Environmental Improvement Project (CEIP) - to identify and develop a suitable waste disposal facility for the Greater Colombo Area (GCA).
  - The Urban Development and Low Income Housing Project funded by the Asian Development Bank addresses solid waste management in selected LAs outside the Greater Colombo Area.
  - Bilateral donor agencies including Japan International Corporation Agency (JICA) and the Australian Agency for International Development (AusAID) have commenced programmes in waste transport and disposal.

"Wasted Opportunity"

The key component of the World Bank funded SWM Project was to design and construct a fully engineered sanitary landfill and a 100 tonne per day pilot composting plant. This facility was designed to treat and dispose of 1200 tonnes per day. A site was identified at Alupotha, Meepe (1998) and an Environmental Impact Assessment carried out. Bids were received from international contractors for this turnkey project. However, due to various reasons including lack of political commitment the tender process was cancelled. This site was not reconsidered due to objections by NGOs and local residents (NIMBY syndrome) even though the Central Environmental Authority approved the EIA.

As a result the sanitary landfill which was to have been operational by 1999 never got underway. The concessional loan of US $ 12 million by the World Bank for the construction of the sanitary landfill was withdrawn. This was the second time that a World Bank financed solid waste management project for the GCA was cancelled. The first project, which began in 1993, was a sanitary landfill located in Welisara. The country lost an opportunity to solve the disposal problem in the GCA, the area facing the most severe crisis.

This experience demonstrates clearly that when investment opportunities are available, unless there is strong political will and commitment, no solutions would be forthcoming in the foreseeable future.

3.2.5.8 Financial Management

Many LAs spend more than 80% of solid waste management expenditure on collection and transport. Little or no costs are incurred on disposal. The main source of revenue for the LAs is through the collection of property rates and taxes. Local Government ordinances do not permit the levying of fees for services rendered in connection with solid waste collection. However, if environmentally acceptable means of disposal methods are to be implemented it would be necessary to levy a user fee. The relevant acts would therefore require amendment.

3.2.5.9 Public Awareness

It is necessary to carry out awareness programmes to encourage minimisation of waste generation at source. These programmes should include waste minimization and recycling possibilities as well as emphasise health impacts of haphazard waste disposal. Such programmes have commenced in some schools and the scheme should be encouraged and promoted.

3.2.6 Recommendations

The fundamental problems and issues associated with solid waste management could be identified as:

- Failure to implement medium to long term plans at the national, provincial and local levels
- low priority for waste disposal at decision making levels
- Ad-hoc arrangements for waste disposal by each LA, giving rise to high environmental and social costs.

To improve the present system of solid waste management it is necessary to:

- Develop plans based on principles of integrated waste management systems - this would provide a rational and coherent mechanism for developing and managing the entire SWM system. It should include plans for waste reduction/re-use, feasible treatment and disposal systems
- Form a strong centralised/regional authority to co-ordinate SWM initiatives
- Enforce existing environmental regulations and draft new policies and regulations as required
- Develop alternative methods for waste management depending on the waste quantities and characteristics. There is no 'single solution' for the entire country since solutions suitable for urban areas may not necessarily be the best option for rural areas
- Provide incentives for enhancing materials recovery, recycling and re-use
- Enhance community-based pilot project for composting and materials recovery. Encourage private sector participation.

Improved solid waste management practices require firm commitment and the ability to make difficult decisions. If timely decisions are not taken it is inevitable that the situation will only worsen.

Refrences

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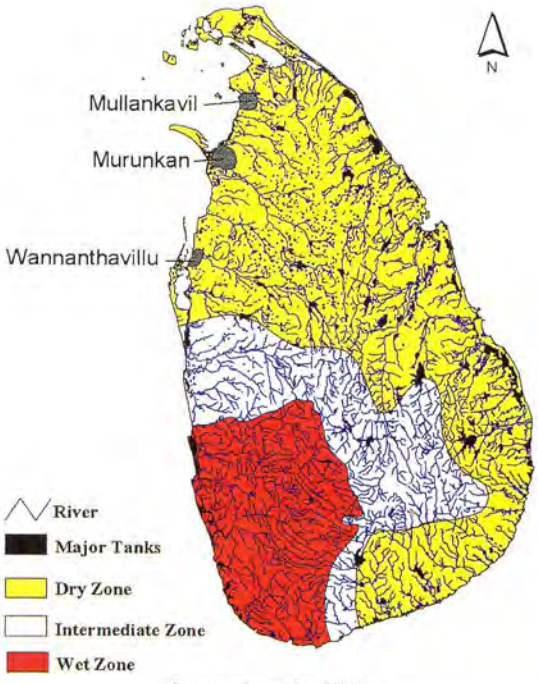
3.3 POLLUTION OF INLAND WATERS

3.3.1 Introduction

Sri Lanka is endowed with rich water resources emanating from the central highlands that receive rain during the monsoons. The mean annual rainfall ranges between 900mm to 6000mm, with an island wide average of about 1,900 mm, which is about two and a half times more than the world annual mean of 750mm. The country can be divided into wet and dry zones with a mean annual rainfall of 2424 mm and 1450 mm respectively. The total volume of fresh water received annually is 13,230 million m3. The average annual river flow, which is 31% of the rainfall, is 40,680 million m3 (Natural Resources of Sri Lanka, 1991). Sri Lanka has abundant water resources in aggregated terms, but this overall picture is misleading owing to the high degree of variation in the availability of water, both seasonally and regionally (Anon 1998a)

Surface waters are carried radially from the central hills through 103 distinct river basins covering 90% of the island. Their catchment areas range from 9 to 10327 sq. km. and 18 river basins have catchment areas of over 1000 sq. km. The Mahaweli is the longest river draining 16% of the country and carries water from the wet zone to the dry zone. Some rivers produce shallow flood plains in their lower reaches referred to as 'villus', which may be permanently connected to rivers or remain isolated. Flood plains associated with rivers are best represented along river Mahaweli, the Kala Oya and the Modaragama Aru. The most extensive flood plain of the Mahaweli covers around 50,000 hectares. Riverine marshes and flood plains convey flood waters to downstream regions.

Water Resources of Sri Lanka and Climatic Zones based on Rainfall



Source: Jayantha, HMP

Many of the 41 wetland sites are facing threats owing to conversion into housing, agriculture and salt pans, with some affected by siltation and pollution. In the southwestern coastal zone, wetlands act as sponges by gradually releasing flood waters and storm water received from urban areas.

Sri Lanka's inland waters include man made lakes and ponds and marshes, costituting one of the highest densities in the world. The area under water bodies covers 2905 sq. km. or 4.43% of the total land area. The dry zone possesses a sophisticated irrigation system of reservoirs and canals built mainly for rice cultivation. There are 309 major irrigation reservoirs (serving over 80 hectares each) and nearly 18000 minor irrigation reservoirs, of which around 12,000 are currently operational. Some of these reservoirs date back to 4000 years. (Brohier 1934).

Reservoirs can be categorized into two distinct groups, the recently constructed irrigation and hydro power reservoirs such as Kotmale, Victoria and Randenigala in the upper montane course of the Mahaweli River, and the older shallow multipurpose irrigation reservoirs of the lowland dry zone. Both types of reservoirs are linked to an aquatic network under the control of Mahaweli Authority of Sri Lanka (MASL).

The estimated groundwater potential of the country is 780,000-hectare meters per annum. (Natural Resources of Sri Lanka, 1991). Rainfall is the primary source of groundwater. Its contribution to the groundwater recharge is estimated to be 7-30% (Anon 2000), or 200 - 600 mm/year. The rate of recharge varies from one geologic formation to another.

There are several aquifers with substantial groundwater resources in the limestone area in the north and west of the Island. The Vanathavillu basin

in the Northwest is a major aquifer with the highest potential spreading over 40 km2 with a water potential 5-20 million m3/year.

Intentional needs causing unintentional adversities

Rivers often form the main link between interacting ecosystems. There are two aspects of water pollution: the human impact on aquatic systems such as rivers, wetlands, reservoirs and ground water. They arise as a result of direct changes to water bodies through river diversions, the connecting of water sheds, damming of rivers which fragment their longitudinal integrity, and the regulation of rivers which break the lateral gradients or links between land and water. The indirect effects are caused by impacts of land use in the catchment areas such as deforestation, plantations and human settlements.

Water resources are at times, subjected to conflicting multiple demands such as domestic uses, agriculture, health and sanitation, inland fisheries, hydropower generation, industrial and commercial uses, recreational and other activities.

The stage has been reached where demand for water exceeds availability in some regions, which may lead to a widespread problem of water scarcity in the future with increasing population, urbanisation and industrialisation. Well planned management of water resources is required to harmonise the multiple uses of aquatic resources and avoid possible conflicts in future.

3.3.2 Pressure

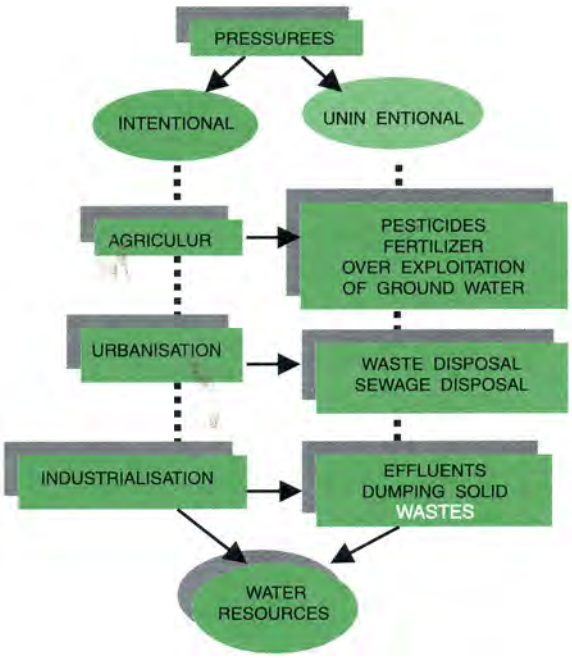
The major intentional (direct) pressures on water resources are agriculture, urbanization and industrialisation that change land use patterns. Excessive use of agrochemicals and chemical fertilisers, release of industrial effluents, domestic waste and sewage and dumping of solid waste into waterways cause unintentional (indirect) pressures. These pressures collectively interact resulting in complex impacts on water resources.

Drier regions have a major stake in agricultural GDP

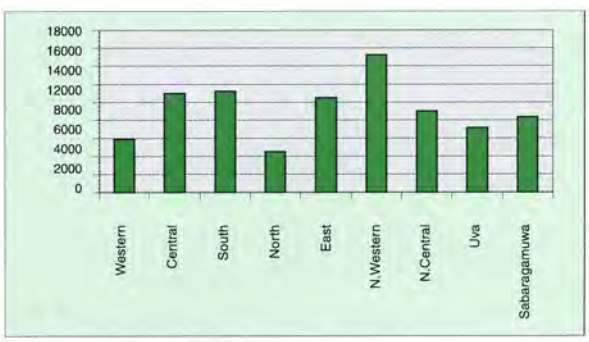
3.3.2.1 Agriculture

Agricultural activities exert significant pressures on water resources. Rice, as the staple food of the country, occupies about 56% of arable land and uses about 90% of the available water (Anon 2000). Agriculture is the most important sector in the economy of Sri Lanka in terms of land utilisation (37110 sq. km) and the employment potential. Agriculture contributes 20% to the total GDP of the country.

Pressure on Water Resources



Regional Breakdown of GDP in Agriculture Sector - 1995

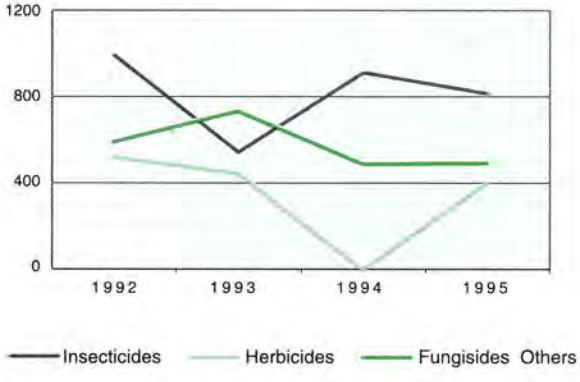


Source: Data from Dept. of National Planning

Government agricultural policies were focused mainly on irrigation for the cultivation of rice, which is the staple food of the country. The Accelerated Mahaweli Development Programme, which commenced in 1978, significantly increased the irrigated area to 1.9 million ha (Steele et al 1997). The development of the agricultural sector enhanced the application of agrochemicals and fertilizers and contributed largely to water pollution.

The use of ground water resources for agriculture is prevalent particularly in the dry zone of the country. In some areas such as Puttalam, Mannar, Paranthan, Kilinochchi and Mullativu, groundwater is over exploited. Around 12000 large diameter shallow wells are in use in the dry zone to irrigate highland crops.

Agrochemical Usage



Sour ce: Statistical Compendium of Environmental Statistics (1998) Dept. Census and Statistics

3.3.2.2 Urbanisation

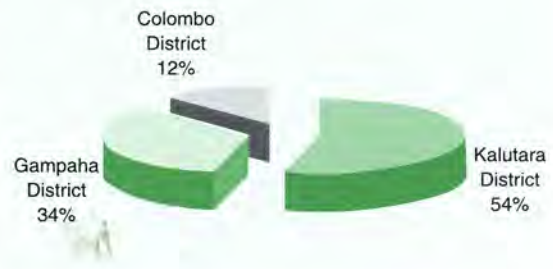
The population in urban areas has increased from about 11% in 1871 to 25% in 1995 (Abeykoon 1998). The pace of urbanization in the future is likely to be rapid. The highest proportion (51%) of the urban population is centered in the Western Province which includes Colombo, Gampaha and Kalutara districts.

According to Abeykoon (1998), Colombo covers 1% of the land area (652.42 sq. km) and carries 11% of the total population at a high density of over 3213 persons per km2. Gampaha and Kalutara towards the north and south of Colombo have population density of 609 and 1265 persons per sq. km seperately.

Urbanisation and the lack of adequate waste disposal and management facilities has resulted in water pollution by to the discharge of domestic waste into water ways. The larger cities such as Colombo, Galle, Jaffna and Kandy have serious problems in the disposal of liquid waste, sewage, industrial effluents and industrial and domestic solid waste.

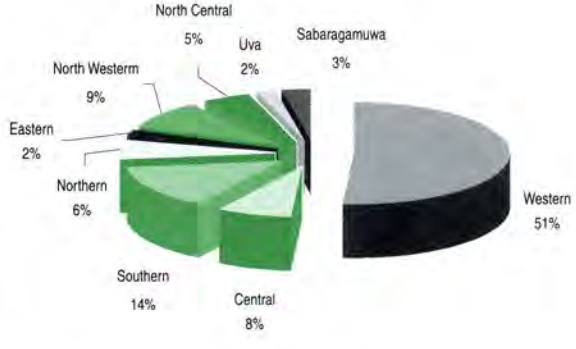
It is estimated that 550,000 persons live in low income settlements in the CMR which could be classified as: (a) slums (b) shanties (c) unserviced semi-urban neighborhoods (d) labour quarters of Local Authorities and (e) relocated new settlements.

Distribution of Urban Population in CMR 2010



Source : CMR Team UDA, Anon 1998

Urban Population by Province



Source : Statistical Abstract 1995

According to the National Water Supply and Drainage Board (NWSDB 1993), about 300,000 persons in the Greater Colombo area live in slums ("community gardens") which lack basic utilities such as safe water and toilet facilities.

It is revealed that only 19% of the population in CMR was served by piped sewers and 59% by onsite facilities. The total quantity of excreta disposed in this area is estimated at 726 metric tonnes/day, 59% of which is released into earth through septic tanks and pit latrines. 138 MT sewage are released daily into waterways owing to grossly inadequate sewerge systems. On-site systems such as pit latrines also contaminate ground water.

Extensive use of agrochemicals lead to higher level of water pollution

The only conventional sewerage system in operation in the CMR at present is in the Colombo Municipal Council (CMC) area. This aging sewer system

Growth of Urban population, 1991 - 2021

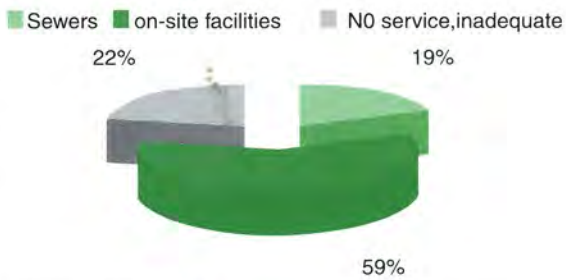
	1991	1996	2001	2006	2011	2016	2021
Urban population ('000)	4,315	4,638	5,110	5,760	6,659	7,834	9,092
Percentage Urban	24.9	25.3	26.4	28.3	31.3	35.4	39.8
Percentage growth rate	-	1.5	1.9	2.4	2.9	3.2	3.0

Source Abeykoon 1998

comprises 250 km of gravity main sewerage, 20km of force mains, 13 pumping stations and 2 long ocean sea outfalls, which cover approximately 80% of area. There is no direct discharge into the environment from the city sewer system. However, overflows, designed to prevent sewage flooding in times of heavy rainfall, or during an interruption of power, discharge sewage directly into waterways. This results in pollution of receiving waters such as the Kelani River and Beira Lake (Anon 1999).

The highest density of housing is within the CMR, which enhances pollution through waste water discharges.

Sewage Disposal in Colombo



Source : Anon, 1998.

Land Area and Density of Housing in the Colombo Metropolitan Region (CMR)

District/region	Land Area (ha)	Housing units	Density
Colombo	69,790	389,188	17.0
Gampaha	139,870	360,991	5.0
Kalutara	159,760	197,182	5.1
CMR	369,240	947,361	7.0

Source : UDA 1996

It has been estimated that of the total waste water generated (370,000 m3 / day in the GCA), 90,000 m3 / day are discharged through ocean outfalls. The remaining 280,000 m3 / day re-enters the environment as waste water (NWSDB, 1993).

3.3.2.3 Industrialisation

Sri Lanka is shifting her focus from agriculture to industry as is evident from Gross Domestic Product (GDP) from 1980 to 1996. The large manufacturing industries of the country include cement, paper steel, petroleum refining, sugar, ceramics and textile. Industries in the rural areas are small cottage units using traditional technology.

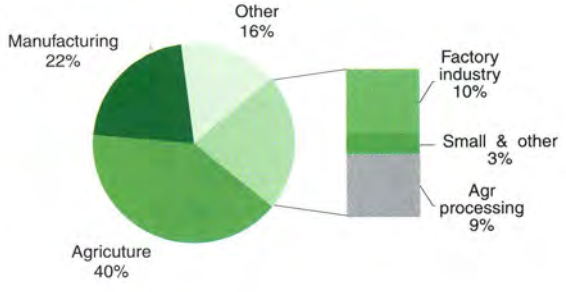
The urban sector is dominated by small and medium sized manufacturing industries, including tanneries, textiles, batiks, garments, food processing, paints,

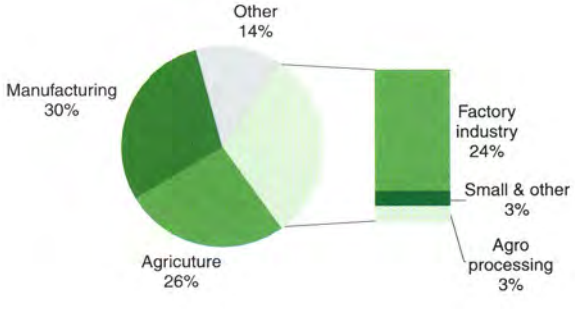
varnishes, cosmetics and other chemical products. The spatial distribution of industry shows that more than 50% are located within 12 kilometers from Colombo Fort, 80% within 21 kilometers and more than 90% within 27 kilometers of the city center.

Most of the industries in Colombo are located in Ratmalana with industrial estates in Homagama and Orugodawatte in the Colombo district and Malwatte and Peliyagoda in the Gampaha district. Colombo and Gampaha account for nearly 80% of industries in the country.

The major effluent generating industries have been identified as textile dyeing and bleaching, food processing, leather tanning, metal finishing, agro produce, sugar, distilleries, breweries, pulp and paper, leather and tanning and mineral products. According to CEA data, about 50% of the industries with EPL possess pollution abatement measures.

Sectoral Combosition of GDP





Source: Stastistical Compendium of Environmental Statistics, Department of Census and Statistics (1998)

Industrial Areas in Grater Colombo with Proposed Areas for Future Industrialization

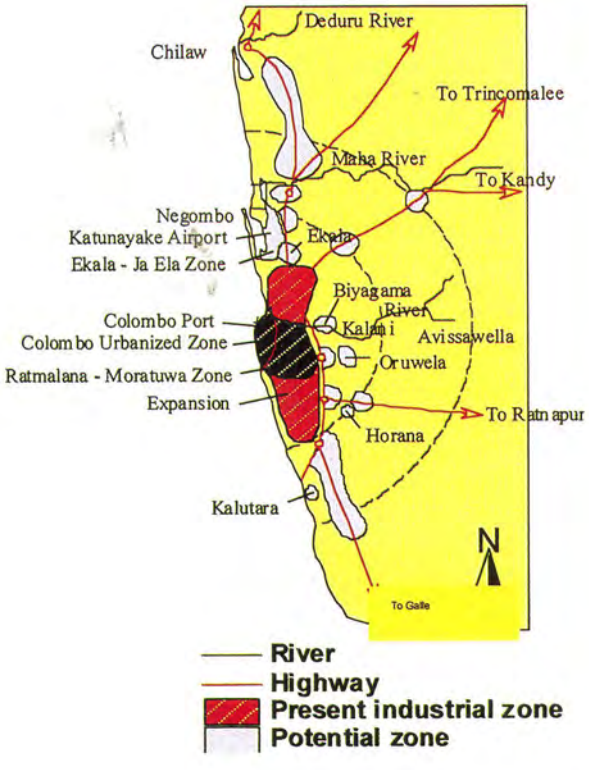
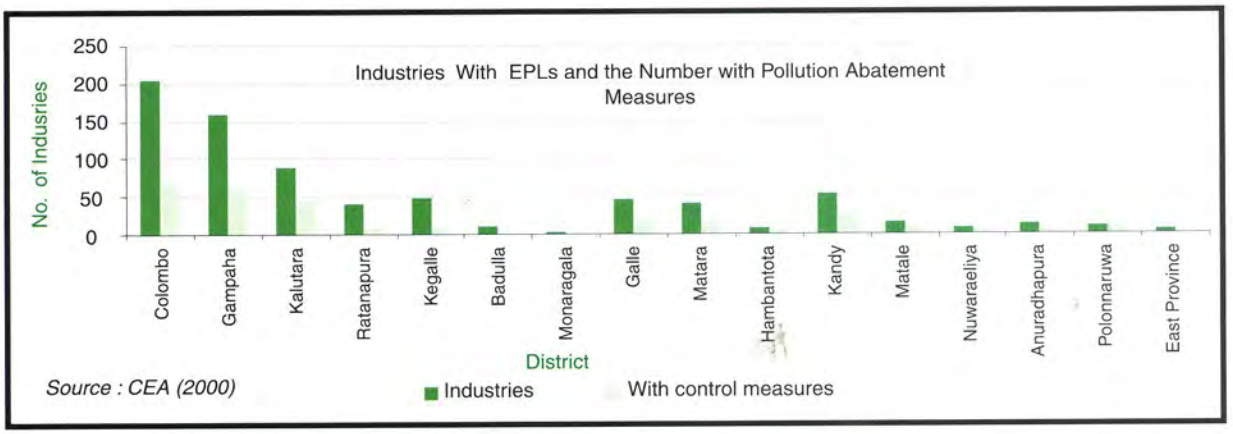


Diagram- Swarna Piyasiri & W Senadeera

Composition of Solid Waste of Katunayake Export Processing Zone

Components	Tonnes per day	%
Fabric off-cuts	12	66.7
Rubber and rubber based items (Synthetics)	3	16.7
Paper and cardboard	1.6	8.8
Putrescible waste (Canteen waste etc)	1.4	7.8
Total	**18**	**100**

Source-Anon 1998



Disposal of garbage by open dumping is the prevalent practice of most Local Authorities.

Industrial parks set up by the Government provide for the use of clean technology and

central water treatment facilities.Industries outside these parks, especially those established prior to the introduction of environment standards adopt engineered waste disposal methods in order to aviod contamination of adjacent water bodies and ground water aquifers.

3.3.3 State

The major water pollution issues could be categorised as pesticide pollution, nutrient pollution and groundwater pollution due to agriculture and pollution due to industrialisation and urbanisation.

3.3.3.1 Pesticide Pollution

Recent data is lacking on pesticide residues in water resources. As agrochemicals are extensively used in agriculture, there is little doubt as to the existence of pesticides in water and resultant effect of bio-accumulation in animal tissues.

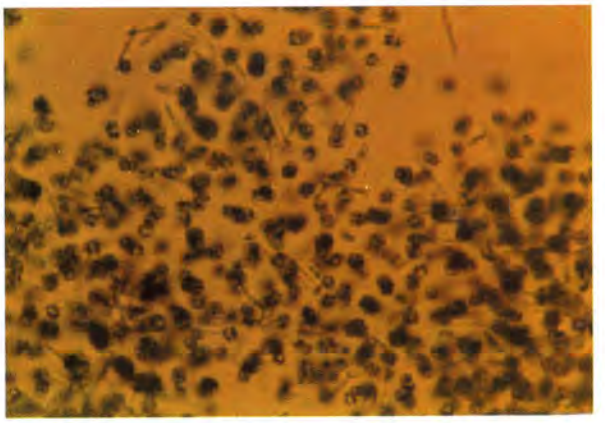
3.3.3.2 Nutrient Pollution

Eutrophication or the process of nutrient enrichment of stagnant waters due to excessive use of fertiliser, is becoming a critical issue. A case study of the problem of eutrophication and blooming in the recently constructed Kotmale reservoir due to excessive use of fertiliser in its upper Kotmale catchment has been undertaken (Piyasiri 1995, 2000).

The consequent risk of high phosphate levels in Nuwara Wewa and to a lesser extent in Tissa Wewa (both in Anuradhapura District) is severe (CEA 1994). Similar studies for the surface waters in Mahaweli System H revealed high agricultural agrochemical inputs (Azmy et al, 1993 and Gunawardene et. al. 1982).

The Kandy Lake and Lake Gregory are also victims of nutrient enrichment. Water quality surveys of many irrigation reservoirs and channels in Mahaweli System 'H' in the Anuradhapura and Polonnaruwa districts were found to contain high nutrient levels.

Eutrophication and Blooming in Kotmale Reservoir



A Case Study on Nutrient Enrichment in Kotmale Reservoir

The Kotmale reservoir is the upper reaches of the chain of upland hydropower and irrigation reservoirs built under the Accelerated Mahaweli Development Project by constructing a dam across a "V" shaped mountain basin. The reservoir was filled upto full supply level in1986. The upper Kotmale catchment area is devoted mostly to tea cultivation with intense fertiliser application.

The objective of the study was to assess the limnological status of the reservoir and to monitor the nutrient loading process via its upper Kotmale catchment. The investigations were conducted from 1986. In 1991, the fifth year after it reached full capacity, the reservoir was covered with a thick bloom of Microcystis aeruginosa. The early results of the investigation which is in progress, indicated the following:

- The Kotmale Oya tributary brings the highest load of nutrients through the upper Kotmale catchment, covered with dense tea estates
- During the rainy season, the nutrient entrapped in the bottom hypolimnetic region of the reservoir was locked due to thermal stratification and was not available to the surface for bloom formation
- The upstream region of the reservoir received high nutrient loads through the Kotmale Oya tributary
- During droughts, when the water level drops below 15m in the upstream region, mixing of nutrients was facilitated and the reservoir reached eutrophic status
- High nutrient concentration (Phosphate and Nitrates), high temperature and high light intensity during droughts were favorable for the initiation of bloom formation in the upstream region
- Bloom formation was thus initiated and drifted towards the dam due to wind action and covered the entire reservoir.

3.3.3.3 Ground Water Pollution

The unconsolidated sands of the coastal areas act as important storehouses for ground water. Due to high porosity and permeability of the sands, rainwater is stored in the form of lens - like bodies resting on salt water with a transition region of brackish water in between.

Fresh water is thus available a few feet below the surface, and in the dry zone coastal areas could lead to severe salt intrusion if ground water is over exploited. About 12000 large diameter shallow wells are used in the dry zone for irrigation with a demand for 8000 more.

The North Western Province is an important example of an agricultural region, which exploited ground water through 130 tube wells and finally suffered as a result of intrusion of salt water in Puttalam, Mannar, Paranthan, Kilinochchi and Mulathivu.

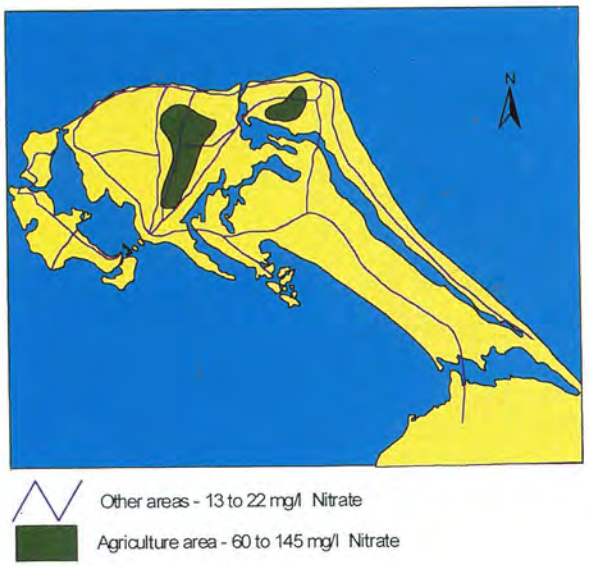
In 79% of the wells, run off of fertiliser and agrochemicals resulted in nitrate concentrations being well above levels advocated by the World Health Organisation (WHO) for safe drinking water, with recorded concentrations of over 200 mg/l. In the islands off the peninsula, 50% of the wells contained nitrates above 10 mg/l.

Leaching of agrochemicals from intensively cultivated soil is responsible for elevated concentrations of chloride, nitrate and potassium observed in many irrigation wells in many irrigation wells in the Kalpitiya peninsula, with nitrate concentrations of up to 40 mg/l . (Lawrence and Kuruppuarachchi 1986).

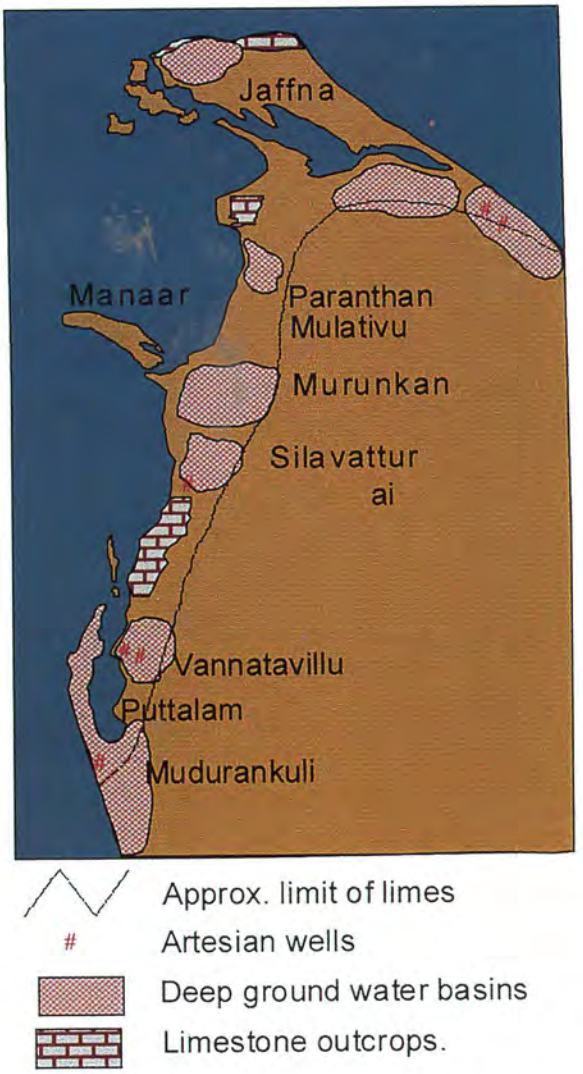
In these agricultural areas, population density is high, and consequently bacterial pollution is common from pit latrine soakways. Soil, which is the most effective layer in protecting groundwater through absorption and biological degradation, is bypassed by pit latrines and increases the risk of faecal contamination.

According to Lawrence (1986), widespread water contamination in the peninsula results from agricultural washouts and pit latrine soak ways. In some areas in Point Pedro, nitrate concentrations ranged from 122 to 174 mg/l due to sewage pollution.

Nitrate Pollution in the Jaffna Peninsula.



Ground Water Resources in the North Western Province



Pollution due to Urbanisation and Industrial Effluents

Urbanisation and industrialisation cause water pollution due to discharge of waste water, sewage, solid waste etc into surface, groundwater and stagnant waters. The condition of the Kelani River and adjacent water bodies indicates the level of such pollution.

The Colombo Urban Area (CUA) is bisected by the Kelani River with heaviest pollution in the western part and less pollution in the eastern and northern parts. All natural vegetation except for some small areas of tropical forest, mangrove and swamp vegetation, in this area, have been destroyed by human activity.

The Kelani River runs through densely populated areas and receives much organic pollution in the last 50 km stretch due to the discharge of untreated faecal matter. It was estimated that the river discharges 36,000 kg/day of COD compared to an estimated 6000 kg/day of COD discharged from the Mutwal outfall some 1500m from the shore. In addition, the concentration of total and faecal coliforms at the mouth of the Kelani is greater than in the seawater above the Mutwal outfall.

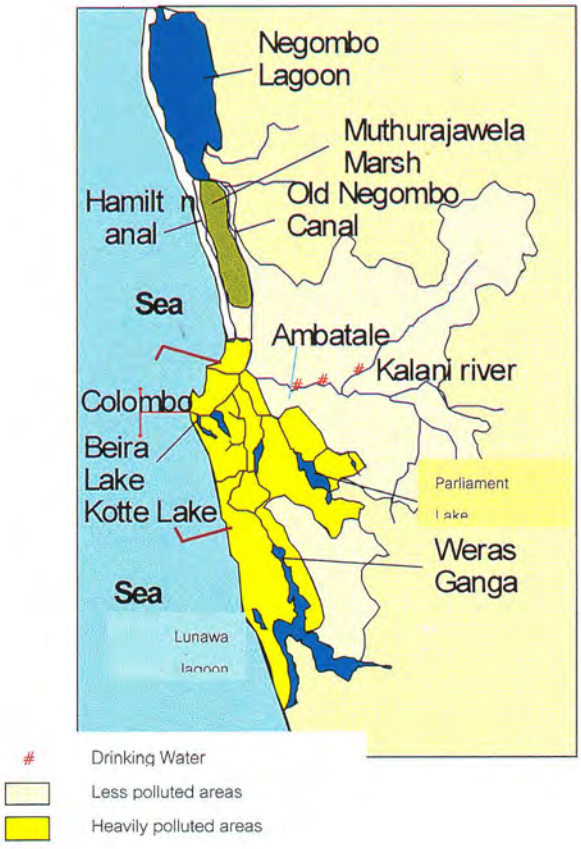
Above figure illustrates the BOD load in San. Sebastian canal where the total load of BOD is 1800 kg/day with industry accounting for only 10% (De Cosse et al , 1997). Thus pollution of the canal is mostly caused by non point sources and by the household sector.

Stagnant Waters

Waste from industries, mainly liquid, has degraded water bodies such as the Beira Lake (80 ha), Parliament Lake (95 ha) and Bolgoda Lake. The Beira Lake in central Colombo in particular is affected by high eutrophication and elevated levels of faecal coliform.

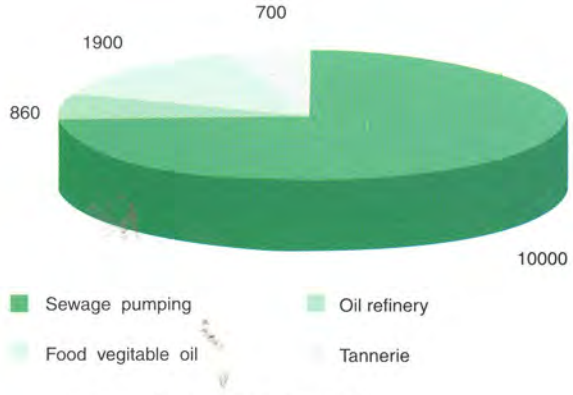
The aquatic life of the Lunawa lagoon has been degraded due to the continued discharge of waste water into its tributaries. The lagoon, which supported a significant fisheries industry, is now devoid of aquatic life and is reported to be covered by 2.5 to 3.0 metres of sludge (Anon 1998 C) and is considered to be biologically dead.

Polluted Areas in the Kelani River Region



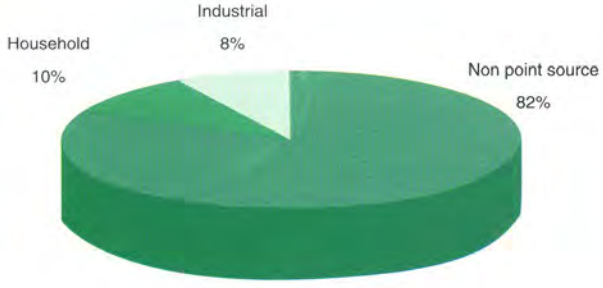
Source: Piyasiri and Senadheera

Waste Sources Affecting Kelani before Ocean Outfall BOD 5/d)

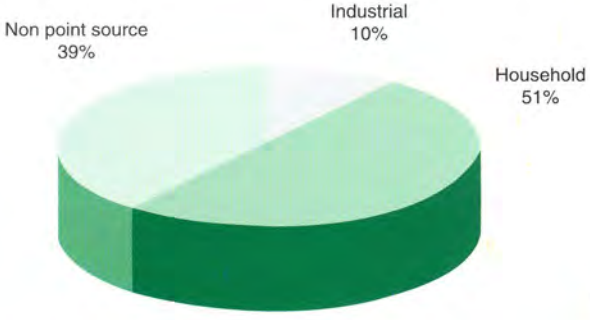


Source: Phillip J DeCosse, 1997

Sources of BOD at Selected Points in the Kelani River



(1 : Lower Kelani River 14,000 kg/day)



(2 : San Sebastian Canal 1,800 kg/day)

Source: Phillip de Cosse, 1987

The Bolgoda lake has not been polluted to the same extent, but the long term impact of continuing discharge of industrial and urban waste into the catchment area will compromise its economic and ecological value (Munasinghe 1995). The Bolgoda Lake is surrounded by industrial areas and many industries, especially in Ratmalana and Moratuwa, discharge waste into Lunawa lagoon or Bolgoda North Lake through the existing system of canals (Bhuvendralingam et al 1994). Waste from domestic, agricultural, municipal, recreational and other activities cause pollution of these waters.

Other Types of Pollution

Sand mining from river beds exceeds the annual deposits and has reached critical levels preventing replenishment of beaches with deposits of river sand.

An exponential growth rate is seen for persons affected by water borne discharges and contaminated fish

Sand Mining in Major Rivers (m3/ Yr)

	1984	1991
Kelani Ganga	630,000	640000
Maha Oya	316,000	630,000
Maha Oya Upstream	-	1,110,000
Kalu ganga	132,000	130,000
Total	**1,078,000**	**2,510,000**

Source: Coast Conservation Department; Research Division- Peoples Bank - Anon 1992

Following table indicates the quantities of sand mined from Kelani River, Maha Oya and Kalu Ganga from 1984 to 1991. Sand mining in the Kelani River has lowered its bed to below sea level resulting in intrusion of seawater which affects the drinking water supply to the city of Colombo. Sand mining is likely to increase in future due to increasing demands for sand for the building industry.

High fluoride levels in water in hard rock terrain are now observed in areas such as Anuradhapura, Polonnaruwa, Hambantota, the south western part of Moneragala district and in Udawalawe. In Udawalawe and parts of the Central Province, a fluoride content of 100 to 200 ppm has been reported which exceeds WHO standards for drinking water (CEA 1995 a). Eppawela and Anuradhpura have the highest fluoride concentrations in ground water (9 mg/l) and in the Polonnaruwa district 15% of the tube wells have shown concentrations above 2 mg/l.

The wetlands consist of marshes connected to rivers, many small, permanent or seasonal ponds, swamps and other water influenced habitats. The wetlands act as "sponges" to absorb floodwaters which is later released gradually. In this respect, they are valuable as a flood control measure. Wetlands are also subject to dumping of industrial and agricultural effluents, municipal garbage including toxic material.. Wetlands act as natural sinks for pollutants such as nutrients, pesticides, toxic materials, petroleum runoff and other hazardous wastes.

3.3.4 Impact

The major impacts on water resources as a result of agriculture, urbanisation and industrialisation are:

1) eutrophication and blooming in stagnant water bodies
2) nitrate pollution in groundwater
3) spread of disease due to organic pollution,
4) reduction of land values near water ways
5) economic loss to the country

The estimated clean-up costs of such damage are substantial.

Many stagnant water bodies such as the Beira Lake, Kandy Lake, Lake Gregory and the Kotmale reservoir have undergone eutrophication and blooming due to nutrient pollution. Eutrophication deteriorates the stagnant waters and toxic substances resulting from degradation of toxic strains of Microcystis can be added to the water, and such toxins affect human and animal health and can cause massive fish kills as in the Beira Lake, Kandy Lake and Kotmale resevoir. Treatment and restoration projects of polluted waters are exorbitant.

Clean up and Damage Costs of Water Pollution (Rs. Million)

Estimated annual Cost of Damage (monetary and physical)		Current/Planned Investments (Capital cost of Cleanup)	
Total estimated cost	1,963	Ratmalana and Jaela wastewater Collection	454
Lost fish sales In Lunawa Lagoon	8%	Beira lake Rehabilitation	500
Land value decline	712		

Source: UDA (1994)

High nitrate levels in drinking water are hazardous. Nitrate is relatively non toxic but can be converted to nitrite by bacteria in the intestine of infants causing the blue baby disease termed ethaemoglobinemia. This disease is rare when the nitrate-nitrogen concentration in drinking water is less than 10 mg/l. Nitrate can react with other substances such as amines which lead to more complicated health hazards such as cancer.

Table above indicates diseases attributed to water pollution in theCMR where more than one third of the people in do not have access to safe drinking water and depend on unprotected sources. Only 17.5% have access to pipe-borne water, 72.9% use deep or shallow wells and the rest use rivers and tanks. (UDA 1994). As many as 20% of wells are unprotected which allows the inflow of polluted water resulting in water related diseases.

Cost due to Pollution of Inland Water Bodies

	1992	1997	2002
Affected area			
(a) Low income	86.536	93.244	100.790
(b) Other	96.074	101.252	105.658
Percentage of (a) affected by waterborne illness and contaminated fish	25%	25%	25%
Number affected	21,600	23,300	25000
Cost of treatment (Rs million)	15	16.2	25,%
Wages lost (Rs million)	6.5	7. 0	17.5
Percentage of (b) affected by illness and contaminated fish	5%	10%	15%
Number affected	4,804	10.125	15849
Cost of treatment (Rs million)	3..3	7.0	11.0
Wages lost (Rs million)	1.4	3.0	4.8
Total cost of pollution (Rs. Million)	**26.2**	**33.2**	**40.9**

(Source UDA (1994),

Unregulated groundwater use for irrigation purposes causes rapid salinity intrusion. River and canal pollution due to urban and industrial waste in the catchment can also affect the groundwater as well as irrigable land. An analysis of well water from land abutting the polluted stretch of the Kelani river and the Meda Ela in Kandy highlights the impact of polluted surface water.

Industrial pollutants are responsible for polluting surface and ground waters in the Weras Ganga and Lunawa Lake, where the rich fish life is almost extinct, and even the little fish that remain are feared to be carriers of disease.

Diseases due to Water Pollution (Greater Colombo Area (1990))
Rate per 100,000

Major diseases	Colombo	Gampaha	Kalutara	Greater Colombo
Typhoid/Para-Typhoid Fever	28	9	2.2	21
Shigellosis	108.2	73	309.2	114.7
Food poisoning	16.7	68.1	857	29.7
Amoebiasis	18.3	20	4.4	17.7
Intestinal infections	691.1	382.2	547.5	598
Malaria	89.9	99.3	61.6	90.2
Dengue fever	1.4	0.5	0	1

Source : Steele et al (1997)

Summary of Cost of Water Pollution in Colombo Metropolitan Area (Rs Million)

	1992	1997	2002
A Human Health costs			
1. Piped water	99	276	452
2.Non piped water	69	79	69
3.Canals & lakes	17	33	48
4.Coastal waters	2	4	14
Sub total	187	392	583
B Land value costs			
1. Kelani river	91	270	456
2. Canals	134	403	1262
Sub total	225	673	1262
Total Cost	**412**	**1065**	**1845**

Source: UDA (1994)

3.3.5 Response

During the post independence period, the development models focused mainly on economic growth and employment creation with little attention being paid to environmental management. This situation has changed significantly during the last two decades and increasing attention is now being paid to the protection of the environment.

Legislation

Many laws have been enacted over the years relating to water issues. The most important include:

- The State Lands Ordinance (No.8 of 1947, Part IX) which provides for the regulation and control of public waters and streams through a system of permits,
- The Irrigation Ordinance (No.32 of 1946 with amendments) which consolidates laws relating to irrigation,
- The Mahaweli Authority of Sri Lanka Act (No.23 of 1979) which enpowers MASL to use and develop the water resources of the Mahaweli River,
- The National Water Supply and Drainage Board Act (No.2 of 1974, as amended) which describes thestatutory duties of the NWSDB to provide water for public, domestic and industrial purposes,
- The Electricity Act (No.19 of 1950, as amended) provides licensing of installations for the generation of electricity. These licences confer all rights necessary for the purpose of electricity generation including the right to use water,
- The Ceylon Electricity Board Act (No.17 of 1969, as amended) describes the duty of the CEB to develop and operate systems for the supply of electricity including the right to use water for hydropower,
- The Fisheries and Aquatic Resources Act (No.2 of 1996) provides for the licensing of fisheries and aquacultural operations which require an allocation of water to carry out approved activities.
- The National Environmental Act No.47 of 1980 with Amendment Act no.56 of 1988, lays down that "no person shall pollute any inland waters of Sri Lanka or cause or permit to cause pollution in the inland waters of Sri Lanka".

The concern shown by successive governments of the increasing level of water pollution and the resultant degradation of the living environment, is clearly evident from policy measures and instruments set in place during the last few decades. These include the National Conservation Strategy, the National Environment Action Plan (NEAP) 1998 - 2001, the Pollution Abatement Strategy and the Wetland Conservation Plan.

The Key Recommendations of NEAP (1998 - 2001)

- Creation of a single authority to guide and coordinate the activities of the institutions involved in water management
- Obtaining agreement on national principles for water allocation and implemening them in major river basins
- Implementing a monitoring program for assessing the level of pollution in water bodies

- Developing and implemening a strategy for managing ground water which will address issues of ground water extraction and ground water pollution.
- Ensuring the location of high polluting industries in industrial estates with central treatment plants
- Strengthening the capability of national and sub national agencies to enforce pollution control regulations more effectively
- Promoting the establishment of a fund financed by industry for private sector management of environmental pollution resulting from industrial effluents
- Assisting the private sector in identifying sources of clean technology
- Streamlining the EIA process by introducing more advanced processes such as Strategic Environmental Assessment. (SEA)

3.3.6 Legal and Institutional Interactions

Degradation of water resources has been recognised as a major environment and social issue. In order to achieve water conservation and for the protection of the quality of water, the following policy measures have been adopted:

1) A National Water Resources Council, supported by the Water Resources Secretariat, have been established to address all water related issues in a holistic manner. This Council will be a high level advisory body comprising government agencies and all stakeholders
2) A Ministry for Water Resources has been established which will oversee the Water Resources Council, the National Water Resources Authority and the Water Resources Tribunal.
3) A Water Resources Law and a master plan for water use are being developed. A national water resources policy will be developed in order to make optimum use of this resource and to resolve competing demands between irrigation and power generation
4) Incentive schemes are being worked out for water conservation
5) Comprehensive development plans will be prepared for major river basins
6) Water supply and sanitation programmes will extend the coverage of safe drinking water and improved sanitation facilities.
7) Criteria will be established for assessment of ground water resources by setting up of surface and ground water quality monitoring programmes, and developing ambient water quality standards
8) Management plans will be formulated for polluted water bodies

3.3.7 Policy Gaps

- One of the main causes for water conflicts and inefficient allocation of water is the lack of coordination between the twenty odd governmental organisations responsible for the quality and quantity of water and are charged with the implementation of about forty water-related laws (ADB 1994).
- Administrative inefficiencies in controlling pollution of water resources.
- Lack of a comprehensive central data base for water quality and industrial activities
- Weak monitoring of the discharge of industrial effluents into waterways

3.3.8 Water Resources Management

Water has not been treated as a key resource needing careful management and protection. A new approach is therefore needed to manage this vital sector. The Government has approved a project titled: 'Institutional Strengthening for Comprehensive Water Resources Management' in 1995. With the assistance of the Asian Development Bank, the Food and Agriculture Organisation and the Government of Netherlands, steps were taken to draft a national water resources policy and comprehensive water legislation. A permanent apex body to oversee water resource management and to initiate a river basin planning process was recommended.

3.3.9 Environmental Impact Assessments (EIA) and Environmental Protection Licence (EPL)

In terms of the National Environmental Act, all new industries which fall into the category of "prescribed projects" are required to undergo the EIA process. Relevant standards for effluent discharge have been laid down in Gazette No 596/16 of 2nd February 1990.

The CEA is responsible for the control of industrial pollution. Local and Provincial Authorities began issuing EPLs to small and medium scale enterprises from January 1994. An EPL is required for a 'prescribed' activity in terms of regulation. 1159/22 of 22nd

November 2000. General standards have been laid down for the discharge of effluents into inland surface waters.

3.3.10 Proposed Ambient Water Quality Standards for Inland Surface Water

The proposed ambient water quality standards are based on a comparison of the standards of other countries.These standards cover physical characteristics, dissolved oxygen content, macro-pollutants, heavy metals and organic micro pollutants. Water quality of inland water bodies are classified into seven classes based on their designated use:

1) Ecosystem conservation
2) Drinking water source without conventional treatment but with disinfect ion
3) Bathing and water recreation
4) Fisheries and protection of aquatic life
5) Drinking water source with conventional treatment
6) Irrigation and other agricultural uses
7) Other uses including:

- cooling water and process water supply for non food industries
- hydropower
- fish survival
- navigation
- controlled waste water disposal

At present CEA is conducting studies to develop load based licensing schemes.

3.3.11 Monitoring Programmes

An appropriate water quality monitoring program for industrial discharges is essential to support CEA's activities. Several agencies have legal responsibility in monitoring including the Mahaweli Authority and the Coast Conservation Department. The National Aquatic Resources, Research and Development Agency (NARA) is responsible for scientific research in this field. The quality of drinking water supplied by NWSDB is monitored in their central and regional laboratories.

3.3.12 Research

Government agencies should cooperate with universities and research institutes to carry out research with a focus on environmental protection. Research should be directed towards catchment management practices and the integration of information to develop suitable strategies.

3.3.13 Education and Awareness Programmes

Several programmes such as Environmental Science, Environment Management, Environmental Economics and Environmental Engineering are offered by universities. However, specialized training in different aspects of environmental management is needed. Awareness programmes should be conducted for the community on the hazards of water pollution and the required mitigatory measures.

3.3.14 Recommendations

- Research is necessary on residues of pesticides in water ways, ground water and in living tissues since pesticide use is intensive, and available information is inadequate.
- Eutrophication seriously affects stagnant waters and proper catchment management practices should be introduced to avoid costly restoration of water bodies.
- Adequate sanitary facilities need to be provided especially in urban areas to prevent pollution of ground water.
- In order to minimise industrial pollution central waste water treatment plants have to be established in industrial parks
- Appropriate solid waste and waste water disposal techniques should be implemented.
- Industries should be located in industrial zones with central waste treatment plants. The adoption of cleaner production techniques should be encouraged

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3.4 LOSS OF BIODIVERSITY

3.4.1 Introduction

Biodiversity is the measure of the world's variety of life. Article 2 of the Convention on Biodiversity (CBD) defines biological diversity as "the variability among living organisms from all sources, inter alia, terrestrial, marine and other aquatic ecosystems and the ecological complex of which th ey are a part; this includes diversity within species, between species and of ecosystems".

Sri Lanka is endowed with rich biodiversity and is considered one of the biodiversity 'hotspots' in the world. High population density and expansion of the human environment have increasingly threatened the island's biodiversity.

3.4.2 Pressure

Loss of biodiversity is due to several pressures arising from the expansion of the human environment.

Population increase is a formidable pressure factor in the low country wet zone

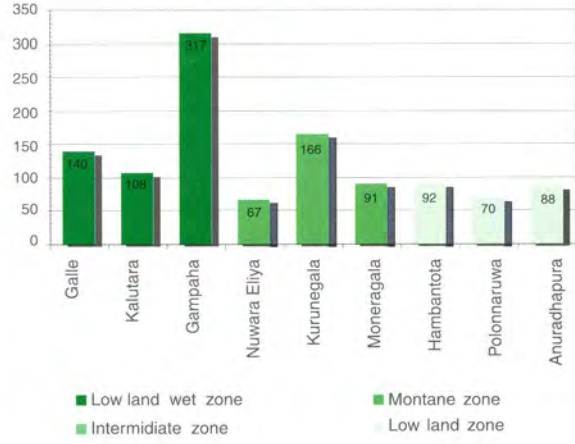
Sri Lanka's Rich Ecosystems

Source : Hewage (2000)

3.4.2.1 Population Increase and Conversion to Other Land Uses

The increase in the Island's population, accompanied by expansion of the land area under urban, agricultural and industrial development have contributed to the loss and reduction of extents of natural forest ecosystems their inherent species as well as genetic diversity. The highest population is in the wet zone districts, which is home to nearly 90% of the endemic biodiversity. The proportion of endemic flowering plants in relation to 100 square miles of land area in the wet and dry zones is 5.71 and 0.11 respectively. The population in a square mile of land in each of these zones is 449 and 141 respectively. These values indicate the relationship between population and endemically in the wet zone.

Population Increases from 1981 - 1994 in Selected Districts of Different Climatic Zones.



Source: Statistical Pocket Book, (1998)

Population Increase and Decrease in Forest Cover since 1871.

There is an inverse relationship between forest cover and population growth

Year	Population (x millions)	Year	% Land Area Under Forest
1871	2.4	-	-
1881	2.7	1881	82
1971	12.7	1890	70
1981	15.0	1956	44
1991	17.3	1983	27
1997	18.3	1992	24

Source: National Atlas

The dense forest cover in Sri Lanka has decreased by 20%, mostly in the dry zone during the period 1956 to 1992. The rate of deforestation from 1960 to 1990 has been estimated at 42,000 ha per year.

Threats to natural forest ecosystems in the wet zone are mainly due to the expansion of tea, rubber, oil palm and other cash crops. In the dry and montane zones the cultivation of cash crops, large-scale development schemes like the Accelerated Mahaweli Development Project and shifting cultivation have impacted on natural forests. Mangrove ecosystems on the other hand, are threatened by the reclamation of land, urbanization and prawn culture. Dry zone ecosystems are also disturbed by cyclones, which fortunately are not frequent. The construction of large reservoirs continues to reduce the extents of natural ecosystems, particularly in the lowland wet and intermediate zones.

In the northern and eastern part of the Knuckles range, the forest undergrowth in 2,400 ha has been cleared for cardamom cultivation. Although cultivation is now curtailed, the absence of juveniles and saplings of the canopy species to replace adults, will require remedial measures. The ideal option is to convert these cardamom plantations to their original vegetation.

Political unrest, particularly in the north of the Island, also contributed to the degradation of natural forests, through clear felling, illicit removal of timber and fuel wood and hunting. Noise pollution adversely affects the animal population. Large scale agricultural and irrigation projects and settlement schemes have also reduced the extents of these forests.

3.4.2.2 Removal of Materials / Species from the Wild

Removal of timber and other forest products affects biodiversity both at species and genetic levels. It also leads to degradation of the quality of the ecosystems.

Forest wood products: In the recent past, about 7 % of firewood and over 22 % of timber consumed were obtained from natural forests . The moratorium on logging natural forests has considerably reduced the impact on biodiversity although some degree of illegal logging still continues. The increasing demand for forest products, inadequate protection of forests and relatively easy access to resources lead to forest degradation, particularly near forest boundaries. Such peripheral boundary areas are also degraded where exotic plantations prone to fire abut the natural forest. Fire in these plantations spreads easily into the natural forest.

Non-wood forest products: Non-wood forest products extracted from forests include all 10 species, of small and large diameter rattans (Calamus spp.which include 8 endemics), bamboo (Ochlandra stridula, Bambusa bambos), many different types of medicinal plants like Bin Kohomba, Weniwelgeta, Kothala Himbutu, Rasa Kinda (Munronia pumila, Coscinium fenestratum, Salacia reticulata, Tinospora cordifolia respectively), multipurpose trees like Kitul, Beraliya, Hal, Wood Apple (Caryota urens, Shorea spp., Vateria copallifera, Limonia feronia respectively) and other domestic products like roof thatching material from Beru (Agrostistachys intramarginalis), and resins from several different Shorea spp., Hal and Kekoona (Canarium zeylanicum). In species like cane or the medicinal vine weniwelgeta (Coscinium fenestratum), removal of the whole plant does not allow the species to fruit, drastically reducing regeneration, and in turn their adult populations as well.

Mining for precious stones: Mining in natural ecosystems in the wet and intermediate zones result in the complete removal of natural vegetation. In some areas, such as the Peak Wilderness, Rakwana-Deniyaya in the Ratnapura district and the Matara district damage has been considerable.

Sand Removal: Sand is mined for commercial purposes in all major rivers. This not only damages the riverbed and pollutes the water, but also greatly reduces the amount of sand being carried to the seashore. Consequently, the sea sand washed away due to wave action is not replenished by the inflow of sand from rivers and results in severe coastal erosion. Mining sand from rivers also leads to intrusion of salt water, which in turn affects the riverine fauna and flora.

Removal of wild species

Wild species have been increasingly collected for commercial purposes. Ornamental aquatic fish and plants for the aquarium trade, ornamental plants like orchids and ferns, and wild relatives of agricultural and medicinal species are now being collected. Among the freshwater fish, 75% of the indigenous fish species, including 21 endemic species, are collected from the wild. The largest collection of fish species from the wild for export includes Rasbora vaterifloris, Puntius nigrofasciatus, Puntius titteya, Puntius cumingii and Belontia signata. In inland aquatic habitats water plants collected illicitly from streams belong to the species, Cryptocryne, most of which are endemic, and Lagenandra.

Coral Mining and ornamental marine species: Coral is the principal source of lime used in the construction industry. Coral extraction by reef breaking reduces spatial heterogeneity, a key characteristic that promotes the diversity of the coral inhabiting biota, including hermatypic or reef building corals.

Over 200 - 300 marine fish species and invertebrates are exported for the aquarium trade. With little monitoring of the harvest, over exploitation is inevitable and affects the diversity of these reefs.

Removal of Coastal Vegetation:

Over harvesting of firewood, removal of branches for brush pile fishery, clearing mangroves and salt marshes for agriculture, aqua culture, salt pans and building construction lead to a reduction in both habitat diversity and coastal biota.

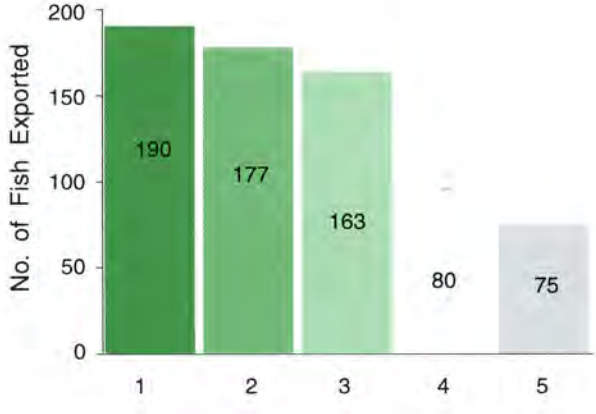
3.4.2.3 Competition Between Invasive Exotic/Domestic Species and Indigenous Species

Over the years, a large number of exotic plant and animal species have been introduced into Sri Lanka either accidentally or intentionally. Some of these species have escaped into natural ecosystems and are now overrunning the indigenous species.

Invasive Species displacing natural vegetation adversely affects the species and genetic diversity of ecosystems

In a few instances, some indigenous species in their natural habitats have rapidly expanded their populations and reduced species richness e.g. in the Knuckles range, the bamboo species, Davidsea attenuata (Bata), is fast replacing the typical montane tree species. Similarly, in the Victoria-Randenigala-Rantambe Sanctuary, another bamboo species, Bambusa bambos (Katu Una), is rapidly increasing at the expense of the characteristic species of the tropical moist semi evergreen forests.

Quantities of Five Ornamental Endemic Fresh Water Fish Exported in 1994 (*000)



Due to the lack of grazing land, large numbers of domesticated buffaloes and cattle are illegally driven into the National Parks for foraging. These animals compete with wild life in the park for fodder and water resources.

In the coral reefs, the increasing population of green algae Halemeda smothers the beautiful live coral. Similarly, the Crown of Thorns starfish predates heavily on coral, thereby damaging the reefs.

3.4.2.4 Lack of Understanding of Scientific Management

Scientific management of natural ecosystems is still in its infancy. Monitoring the condition of these ecosystems and initiating timely measures to counteract adverse changes have not received the attention it deserves. Until the latter part of the 1980's, management of forest and grassland ecosystems was largely limited to protection, commercial extraction of timber and control of visitor activities.

However, the recent past has seen a significant improvement in management strategies. With the ban on logging in 1990, commercial extraction of timber from natural forests have been curtailed .The management of most inland aquatic habitats, has also been poor as seen in the examples below:

Excessive use of agro chemicals pollute inland water bodies and consequently adversely affects aquatic ecosystems.

a) In Horton Plains, the rapidly increasing sambur population, if unchecked, may lead to over browsing in the natural forest. Continuing forest die back and an increasing number of vehicles and visitors causes problems such as garbage disposal, pollution of streams by washing vehicles and the discharge of pollutants into waterways. Predation of indigenous fauna e.g. the endemic Calotes nigrilabris, by the increasing numbers of scavenger crows is also a problem. These issues need to be addressed urgently.
b) In Bundala, the increasing feral buffaloe population competes with other herbivores for fodder and quality water. The rapid invasion of the thorn scrub by Prosopis julifera and Opuntia delenii at the expense of the indigenous species and the changing salinity levels in its lagoons as a result of the construction of the Lunugamvehera Irrigation Project need to be resolved.

c) In the Udawalawe National Park and Victoria-Randenigala-Rantembe (VRR) Sanctuary, prevention of fires has led to the invasion of savannas by Lantana camara followed by other tree species. This woody ground layer is less attractive to herbivors

compared to grass. Controlled fire is an essential tool to maintain quality fodder required to sustain herbivore populations. Fire is all the more necessary in the intermediate zone where the mild climate naturally favours woody vegetation. In the arid zone, as in Yala, the long dry season keeps back the scrub naturally, unless weedy species like P. julifera and Opuntia take over. Granivorous birds and other fauna and flora, dependent on the grassland habitat, would also be affected adversely if timely remedial measures are not taken and ecosystem/habitat diversity maintained in these reserves.

d) Reduction in the marsh habitats and popularisation of hybrid varieties has led to the loss/reduction of native varieties of rice.

Some Invasive Species in Different Natural Ecosystems.

Ecosystem	Plant Species Species	Animal
Thorn Scrub Bundala National Park (NP)	Prosopis julifera, Opuntia delenii	Feral buffalo
Savanna (Victoria-Randenigala-Rantambe sanctuary, Udawalawe National Park)	Lantana camara	Feral buffalo
Stream and River Banks Low land Wet Zone Intermediate zones Clusia rosea,	Dillenia suffruticosa, Annona glabra Mimosa pygra, Parthnium hysterophorus	Golden apple snail
Submontane Forests	Wedelia trilobata Miconia cauvalescens	
Low land Wet Zone Rain Forests	Weddelia trilobata, Clidemia hirta	Giant African Snail
Montane Zone Wet Patana Grasslands (Horton Plains) Montane forests Montane Streams (Horton Plains/Peak Wilderness)	Ulex europeus Cestrum auranticum, Eupatorium repens	Common Crow Trout
Marsh and/or Aquatic Ecosystems	Salvinia molesta, Eichhornia crassipes	Golden apple snail, Thilapia, Knife Fish, Tank Cleaner

Source: Loris Vol 21, No. 2

3.4.2.5 Pollution

Conversion of land to crop production is rapidly increasing and indiscriminate application of agrochemicals is widespread. Agrochemicals and the disposal of industrial waste eventually pollute the waterways. Disposal of industrial waste into waterways contributes to the poor quality of the island's water resources. Algae blooms and fish kills have been reported in the Kotmale reservoir and more recently in the Kandy Lake. Pesticides harm the natural biodiversity of these systems indirectly, through their effect on food chains.

Acid rain has also been reported in Horton Plains the extent to which it contributes to forest die back is not fully understood yet.

Sediment loads in the water also affect the biodiversity in aquatic systems in the reservoirs in both the wet and dry zones and is eventually carried to coastal areas, affecting lagoon systems and coral reefs. Inflow of sediments and pollutants (sewage, industrial effluents) into coastal ecosystems impact on aquatic biodiversity, by depositing debris on reefs and increasing the turbidity of the water thereby limiting sunlight filtering down to the reef.

Increase in temperature of seawater due to global warming also affects the coral reefs in Sri Lanka. The diversity of coral and reef fishes was drastically reduced after the dry weather periods in 1997/98 bleaching the coral. Consequently, animal life usually associated with a healthy reef were adversely affected and drastically reduced the diversity of reef fish and other organisms.

3.4.2.6 Over Visitation

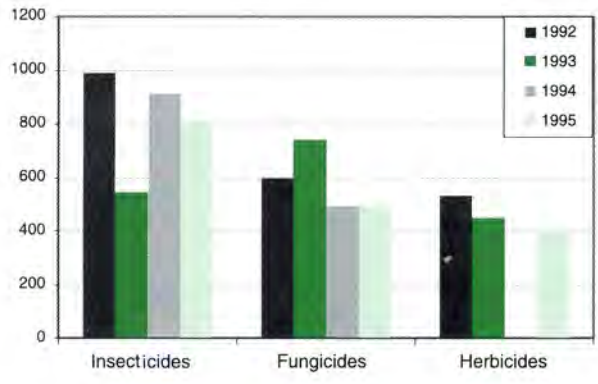
Over the last two decades, the number of visitors to wildlife national parks, forest reserves and other natural ecosystems has increased tremendously. The introduction of subjects like ecology, natural ecosystems and biodiversity into high school curricula has led to large groups of school children visiting these reserves frequently. With the increase in visitor pressure, the problems of solid waste, vehicular emissions and noise pollution have also increased.

The introduction of motorized boats to the Madu Ganga and other aquatic systems has led to bank erosion due to wave action as well as oil pollution. At the Hikkaduwa Marine Sanctuary, overloading boats with visitors has damaged the reef.

3.4.2.7 Under-Valuation of Biodiversity

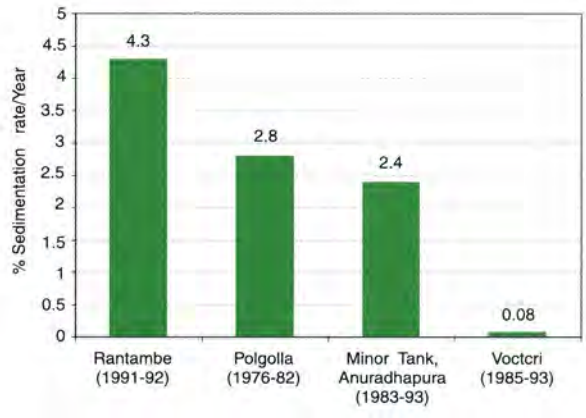
The valuation of biodiversity and its recognition in economic terms is still in its infancy. There is relatively little difficulty in valuing products from natural ecosystems that come into the market. However their service values, like water, soil and genetic resources conservation, amelioration of environment, aesthetic beauty, and the potential for ornamental plants, medicines and food, need to be addressed more in economic terms.

Use of Agrochemicals (in Tonnes)



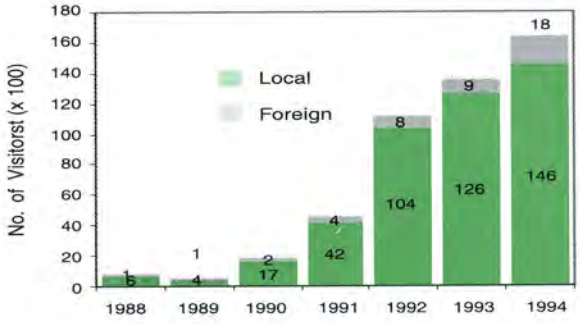
Source: Statistical Compendium, 1998

Sedimentation rates, as a Percentage of Total Reservoir Capacity



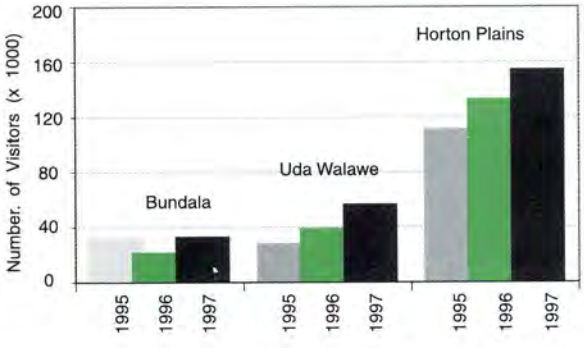
Source: Statistical Compendium, 1998

Visitors to Sinharaja World Heritage Site



Source : Sri Lanka Forester, 1995

Increase in Visitors to Protected Areas (1995-97)



Source: DWLC

3.4.2.8 Inequity in Ownership, Management and Flow of Benefits to Community

Equitable sharing of benefits from the sustainable use of biodiversity to the peripheral communities living around natural ecosystems needs to be developed. Participatory management of reserves has been introduced recently and should be further developed.

3.4.2.9 Activities Detrimental to Biodiversity Conservation

In some instances, lack of awareness and the absence of inter-institutional coordination with regard to biodiversity conservation have contributed to the loss of biodiversity e.g. the use of wetlands for dumping garbage, brick manufacture and land fills.

3.4.3. State

The state of biodiversity in the country can be assessed on the basis of several indicators covering various aspects.

3.4.3.1 Natural Ecosystem Diversity

Sri Lanka has a rich ecosystem diversity for its small size. Its natural ecosystems include
(i) the marine and maritime or coastal ecosystems influenced by the sea, (ii) the natural forest ecosytems, (iii) the natural grassland ecosystems and (iv) the inland wetland ecosytems.

The following ecosystems in Sri Lanka are internationally recognized.

i Sinharaja, as a World Heritage Site and an International Man and Biosphere Reserve.
ii. Hurulu Forest Reserve as an International Man and Biosphere Reserve.
iii. The Western Ghats of India and SW Sri Lanka as a group, as one of the 25 Biodiversity Hotspots.
iv. Bundala is recognized as a Ramsar Wetland Site.
v. Of the 83 wetland sites in Sri Lanka, 41 are in the Asian Directory of Wetland Sites.

The variety and richness of natural ecosystems must be preserved for posterity

3.4.3.2 Present Extent, Distribution and Levels of Ecosystem Fragmentation

The tropical dry mixed evergreen forest of the dry zone represents as much as 54 % of the natural forest cover and 16 % of the total land area in the island. The fragmentation of coastal ecosystems and forests, particularly the tropical wet evergreen forests or rain forests of the lowland wet zone is extremely high.

Freshwater marshes:

These ecosystems supporting rain forests are now confined to one site at Waturana, Bulathsinhala. Others with low statured vegetation may be seen in several areas, including Handapan Ella Plains, east of Sinharaja. The seasonally flooded villus in the Dry Zone too may be included here.

Ecosystem Diversity and their Extents

Aquatic Ecosystem Diversity	Present Extent (ha)
Coastal Ecosystems	
1. Coral reefs	-
2. Sea grass beds	33,573
3. Salt Marshes	23,819
4. Mangroves	12,189
5. Sea shores/beaches	11,788
6. Mud flats	-
7. Lagoons and estuaries	158,017
8. Sand dunes	7,606
Inland Aquatic Systems	
1. Fresh water marshes	10,000 **
2. Rivers , streams, reverine forests	22,435
3. Reservoirs *	170,000

Terrestrial Ecosystem Diversity	Present Extent (ha)
Natural Forest Ecosystems	
1. Tropical lowland wet evergreen forests or lowland rain forests	141,506
2. Tropical submontane forests	68,616
3. Tropical montane forests	3,108
4. Tropical moist evergreen forests	243,886
5. Tropical dry mixed evergreen forests	1,090,981
6. Thorn scrub forests	464,076
Natural Grassland Ecosystems	
1. Wet patanas *	
2. Dry patanas *	65,000
3. Savannas	-
4. Thalawas *	
5. Damanas *	
6. Villus	10,000

Source: IUCN ; Coastal 2000, FSMP; National Atlas

* Man-influenced ecosystems. ** Also includes the villus.

[**Note:** Wet and dry patanas are natural grasslands above 2000 m and man-made grasslands between 500 - 1500 m elevation respectively. Thalawa and damana grasslands are those in the intermediate and dry zone lowlands respectively. Villus are those in the seasonally inundated flood plants and depression]

Rivers and Streams:

There are 103 distinct natural rivers and streams in the Island, with a collective length of 4,560 km. Of them, 80 that flow through the dry zone are seasonal, and 23 that traverse the wet and intermediate zones are perennial.

The 325 km long Mahaweli River flows through all three climatic zones of the Island. Studies carried out on the meso fauna in mountain streams at different elevations indicate a rich diversity of species in areas of high currents.

Reservoirs: Sri Lanka does not have natural lakes, but around 12,000 tanks have been constructed for agricultural purpose (small reservoirs), and range in size from 1 - 600 ha. They harbour a rich aquatic flora and fauna.

3.4.3.3 Indigenous Species Diversity and Their Numbers in Different Plant and Animal Groups

The highest plant diversity is recorded among the flowering plants, followed in decreasing order by the fungi, bryophytes (mosses and liverworts), freshwater algae and ferns. Among the animals, the diversity of vertebrates is relatively well known compared to that of the invertebrates.

3.4.3.4 Endemic Species Diversity (number and distribution)

Plant Species: 927 or 28.3% of the flowering plant species are endemic to Sri Lanka. The majority of these endemics are found in the lowland wet and submontane zones of the island. About one sixth of the fern species are endemic to Sri Lanka. There is little information on the endemic species among the mosses, liverworts, fungi, algae and lichens. In one lichen family (Thelotremataceae) studied in depth, as much as 32 % of the species are endemic to the island, and all of them are confined to the wet zone rain forests.

Animal Species: Among the different vertebrate groups, the highest proportion of endemic species is recorded among the amphibians (65 %), reptiles (52 %), and freshwater fishes (41 %). Among the invertebrate groups studied in depth, the highest proportion of endemics is recorded among the freshwater crabs (100 %) and land molluscs (76 %) .

Like the endemic plant species, most of the endemic fauna too is confined to the wet zone natural ecosystems. Interestingly, all 25 species of freshwater crabs are endemic to the Island and are found in the wet zone aquatic systems.

3.4.3.5 Threatened Species

Over 480 flowering plant species and 90 fern species are assigned threatened status. There is a dearth of information on the threatened status of the species in other groups. Among the animals, over 75% of the endemic species in each of the vertebrate groups, and over 50 -100 % of species in the invertebrate groups are under threat. A large number of species, both plants

Present Areas Under Different Natural Forest Ecosystems

1. Tropical lowland wet evergreen forests or lowland rain forests
2. Tropical submontane forests
3. Tropical montane forests
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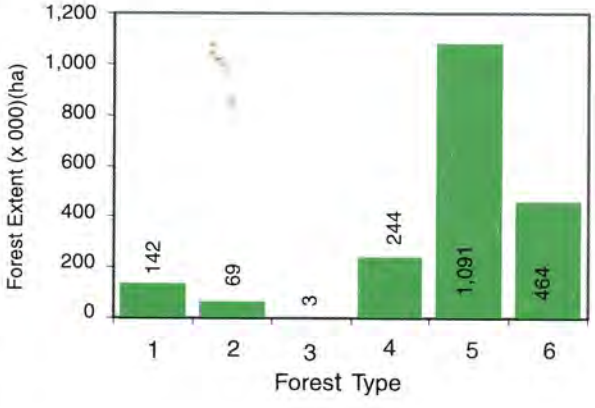
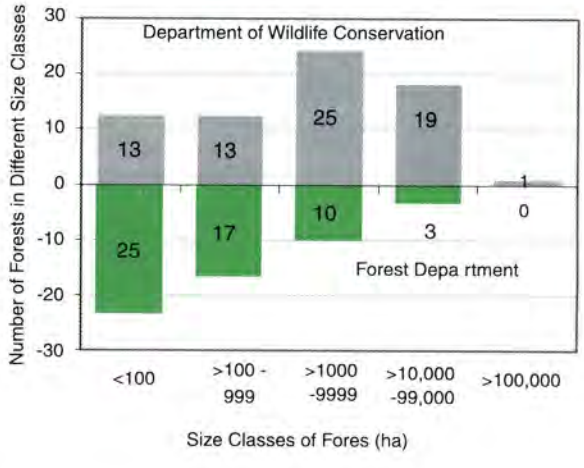
6. Thorn scub forests



Source: Anon. 1995.

All endemic species of fishes, shrimps, crabs and dragon flies are threaten

Level of Fragmentation, indicated by Size of Protected Areas



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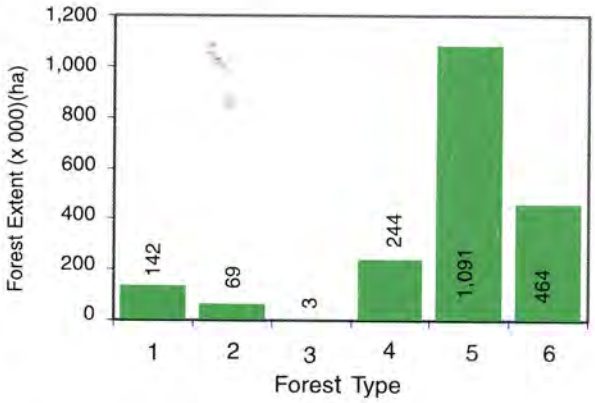

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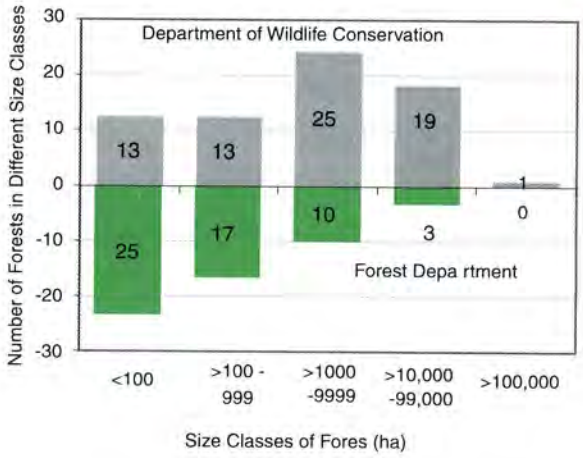

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Sustaining biological diversity is significant because of the country's dependence on fauna and flora for food medicine and domestic utilities

Species Diversity Among Selected Flora and Fauna and the Number of Endemic in Each Group

Indigenous Plant Species	Total No. of Species (No. Endemic)
1. Flowering plants	3770 (927) [a]
2. Gymnosperms	314 (57) [b]
3. Ferns & fern allies	764+ (?) [c]
4. Bryophytes	560+ (?) [d]
5. Freshwater algae	2260+ (?) [e]
6. Fungi	110 (35) [f]
7. Lichens (Thelotremataceae only)	
Animal Species	**Total No. of Species (No. Endemic)**
Vertebrates	
1. Mammals	90 (14) [f]
2. Birds	226 (23) [f]
3. Reptiles	155 (81) [f]
4. Amphibians	54 (35) [f]
5. Fishes*	78 (32) [f]
Animal Species	**Total No. of Species (No. Endemic)**
Invertebrates	
1. Butterflies	234 (20) [I]
2. Land molluscs	250 (205) [g]
3. Dragon flies	117 (52) [h]
4. Crabs*	25 (25) [f]
5. Shrimps*	23 (07) [f]

* (Fresh water only)

Source:

[a] Pers. Comm. S. Wijesundara.
[b]Sledge (1981).
[c]Abeywickrama & Jansen (1978).
[d]Abeywickrama (1979).
[e] Coomaraswamy (1979a,b; 1983, 1988).
[f] IUCN, Sri Lanka (2000)
I] de Arbrera (1998).
[g] Raheem & Butterworth (1998).
[h] de Fonseka (2000)

and animals, have not been collected during the past century. It is likely these are either extinct or on the brink of extinction.

Over 30 species of ferns (Sledge 1981) and over 50 species of flowering plants (NARESA, 1991), including 13 orchids species, are suspected to be extinct. Extinct animals includes the gaur and comb duck (Anon. 1991) and possibly 13 species of snakes. Wild relatives of agricultural crop plants, like those of rice, are severely threatened due to loss of their habitats.

3.4.3.6 Genetic Diversity

Information on genetic diversity of the natural flora and fauna is extremely limited. Genetic diversity of elephants and leopards is lower in Sri Lanka than in the Peninsular Malaysia. A few genetic studies have been done on plants. In these studies, lower within-population genetic variation in Shorea and the endemic genus Stemonoporus, both of family Dipterocarpaceae have been reported in small forest patches, confirming that forest fragmentation and habitat size reduction have lead to their genetic erosion.

3.4.3.7 Genetic Diversity in Agricultural and Medicinal Species

Agricultural diversity (Wijesinghe et al. 1993) in the island includes Oriza sativa (rice) with its 2,800 accessions and 7 wild relatives, 7 coarse grain species and their traditional cultivars, maize and sorghum; 14 grain legumes species; 8 cucurbitaceous, 2 solonaceous and 4 other vegetable (bean, okra, amaranth, chilli) species; 17 root and tuber crop species. The economically useful spices are, 8 species of Cinnamon, Elettaria cardamomum, 3 Piper species with 7 wild relatives, clove, nutmeg, betel nut, vanilla, chilli, and ginger. Others of importance include citronella, 3 species of oil crops and 2 fibre crops. The horticultural species are banana with 9 cultivars and 2 wild relatives, citrus, and over 15 other fruit species.

The medicinal plants in the island include about 1,414 species. Among them, 50 are heavily used, 208 commonly used, and 79 are threatened species (Anon. 1996).

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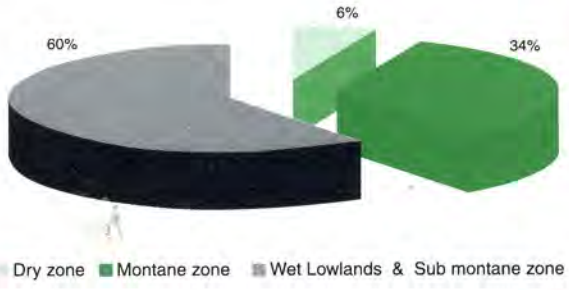
Proportion of Endemic Flowering Plant Species in Different Climatic Zones

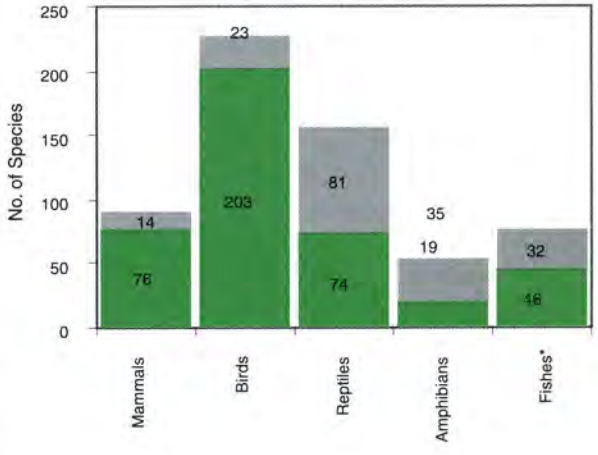
The low country wet zone sustaining the highest proportion of endemic flowering plants



Source: Loris Vol 21 No.2

Species diversity of mammals is relatively high in Sri Lanka in comparison to Islands of comparable size.

Proportion of Non-Endemics and Endemics in Each Group of Animals*
(fishes and crabs in fresh water only)



Source: as in Table entitled : Species Diversity and their Numbers in different plant and animal groups (Page 72)

3.4.4. Impact

The impacts due to loss of biodiversity have been considered under (i) loss and degradation of natural ecosystems, (ii) loss of species and (iii) loss of genetic material.

3.4.4.1 Loss and Degradation of Natural Ecosystems

Marine and maritime ecosystems:

This is discussed at length in section 3.5

Natural forest ecosystems:

With the exception of small extents in inaccessible areas, most lowland rain forests have been selectively logged in the past, to supply plywood and hardwood species. Logging at first was slow using elephants and hand implements. After the 1960's, mechanized logging using chainsaws, skidders, timber jacks and loaders have led to rapid degradation of these forests.

Almost all the tropical dry mixed forests are secondary in origin and about 500 - 800 years old. The distribution of numerous tanks (small reservoirs) in the Dry Zone of Sri Lanka suggests that the forests in this part of the country were subject to shifting cultivation and paddy cultivation at one time or another. Once the reservoir systems were abandoned, the forests slowly returned, accounting for their secondary origin. The dry zone forests have also been intensively selectively logged for their very valuable hardwood timber species such as Ebony (Diospyros ebenum), palu (Manilkara hexandra), satinwood (Chloroxylon sweitenia), pannakka (Pleurostylia opposita) and they have also been exploited for fuel wood. Montane forests have been less harmed, mostly due to their inaccessibility but the fringes have been exploited for fuel wood. Pristine forests are seen in parts of the Peak Wilderness Sanctuary, Hakgala Strict Nature Reserve, Knuckles, Pidurutalagala and Horton Plains.

Number of Nationally and Globally Threatened Species among the Flowering Plants, Ferns, and Vertebrates and Selected Invertebrate Groups

Plant and Animal Groups	No. and (% *) of Nationally Threatened Species		No. of Globally Threatened Species	
	Endemic	Non-Endemic	Endemic	Non-Endemic
Flowering Plants	228 (25)	252	193	233
Ferns	30 (53)	60	20	14
Vertebrates				
Mammals	13 (93)	20	13	0
Birds	22 (96)	39	6	5
Reptiles	32 (76)	7	0	0
Amphibians	31 (89)	2	0	0
Fishes	32 (100)	7	9	0
Invertebrates				
Land Snails	103 (52)	14	0	0
Fresh water shrimps	7 (100)	11	0	0
Fresh w .Crabs	25 (100)	0	0	0
Dragonflies	49 (100)	21	0	0
Butterflies	13 (65)	63	1	0

** % endemics threatened in each group, as a proportion of the total number of endemics in that group.*

Source: IUCN, Sri Lanka (2000).

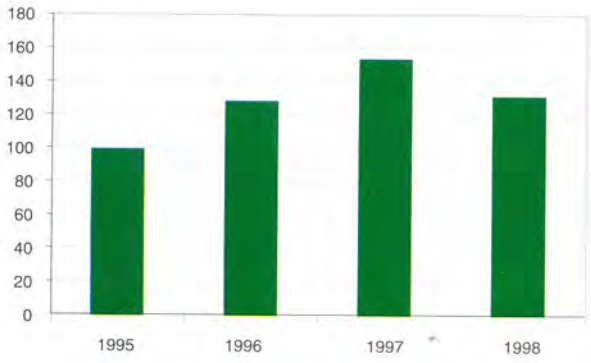
Some areas of these forests too have been mined for precious stones and parts of the Knuckles range and Rakwana-Deniyaya range have been planted with cardamom after clearing the understorey.

Die back of patches of montane forests, evident in the Horton Plains and Knuckles, also lowers the quality of these forests.

Grasslands: While parts of the wet patana grasslands have been converted to agricultural land (Horton Plains, Nuwara Eliya, Knuckles), some of the dry patana grasslands in the Uva Basin have been gradually converted into urban areas, agriculture and exotic mono-specific forest plantations. The thalawas, damanas and villus have been subject to grazing, and some areas converted to cash crop agriculture. The thalawas, damanas and savannas have also been subject to fire, a factor essential in maintaining these ecosystems. However, recurrent fires at short intervals lead to increased erosion, soil impoverishment and soil moisture stress, all leading to colonization by exotic invasive weeds.

The increasing human-elephant conflict in the island is also an indication of the poor quality, fragmentation and possibly the inadequate extents of elephant habitat to support Sri Lanka's largest endangered mammal species, the elephant (Elephas maximus), in its protected areas.

The Number of Elephant Deaths outside the Protected Areas, except in the North and East, due to Human-Elephant Conflict



Source: Pers.Comm. W. Hendavitharana (2000)

Inland Aquatic Systems: The quality of inland aquatic systems is deteriorating due to

- siltation
- deforestation and soil erosion
- inflow of agrochemicals
- urban and peri-urban effluent discharges
- reservoir construction altering the natural river flow
- gem mining and invasion by exotics

3.4.4.2 Impact on Natural Ecosystems, Species and Genetic Material

The degradation of natural ecosystems impacts on the environmental, faunal and floral characteristics of these systems.

Asian Elephant

Source : Heuvage, 2000

Due to terrestrial ecosystem degradation, the physical environment becomes less amenable as a result of higher ground temperatures, lower humidity, and increase in levels of dust, accelerated soil erosion and loss of soil moisture and nutrients. Depending on the severity of the disturbance, it could also result in flash floods and drying up of springs. Some of them could lead to siltation of rivers and reservoirs, raising of river/stream beds, reduction in storage water in reservoirs leading to loss of hydropower and irrigation water

With regard to the biotic component, changes and loss of habitats of plants and animals could lead to reduction in their population sizes. The rare species represented by low densities in particular would be

most affected with further decline in their populations. Some rare species could be wiped out. In forests the epiphytic component of plants, especially the lichens and bryophytes, suffer much harm when the canopy is disturbed.

Animals, molluscs, amphibians, lizards, snakes and plants that live under shade and high moisture conditions would be most affected. Reduction in numbers of individual species could also lead to genetic losses. Fragmentation of ecosystems leads to a reduction in the habitats of animals and plants.

If corridors of vegetation do not connect the fragments, similar to that in the fragments, then the movement of animals becomes restricted. In such cases, exchange of genetic material through seed and pollen dispersal between and among fragments will be hampered, leading to genetic erosion of the species within each fragment.

Natural ecosystems also harbour animals beneficial to agricultural systems. Reduction in numbers of such species due to ecosystem disturbance could reduce crop yields reduce crop yields.

3.4.5 Response

With growing attention being paid to environmental management at both global and local levels, Sri Lanka has responded positively to protect its biodiversity.

3.4.5.1 Establishment and Management of Protected Areas and Buffer Zones

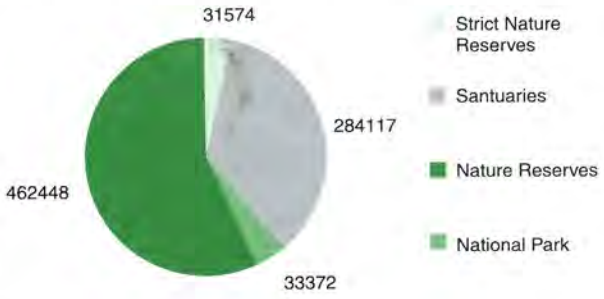
The extent of land set apart for protection of biodiversity in the country is 951,333 ha or about 14 % of the island's total land area. This is a substantial increase from the 1950's when it was only 8 %. Of the island's total land area 12.3 % is administered by the Department of Wild Life Conservation (DWLC) and 1.7 % by the Forest Department (FD), designated as different categories of reserves under the protected area network . The boundaries of reserves are being surveyed and marked to prevent encroachments.

For the management of protected areas a zoning system has been identified. Basically, they include a cultural zone, traditional use zone, a core zone and a buffer zone. Buffer zone management programmes, incorporating the needs of the local people, are now being considered and would include income-generating activities for the local people.

With regard to coastal zone ecosystems, the first coastal zone management plan was prepared in 1990 and in 1992 'Coastal 2000: Recommendations for Resource Management Strategy for Sri Lanka's Coastal Region' was prepared and endorsed by the Cabinet of Ministers in 1994.

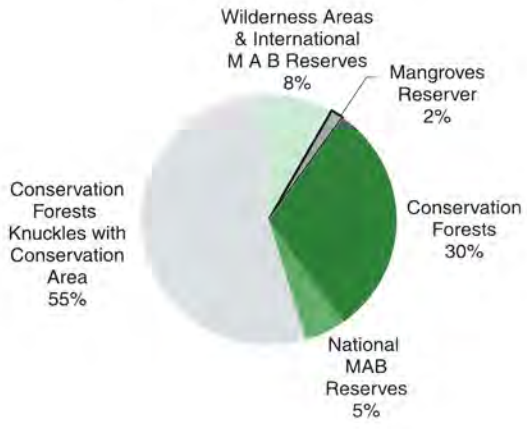
Protected Areas

I. Department of Wild Life Conservation



Source; Anon, 1995

II. Forest Department



Source: Conservator of Forests

3.4.5.2 Ex-Situ Conservation

To a limited extent, a part of the island's biodiversity is under ex- situ conservation. Live collections of selected species and germplasm are maintained in many centers. Whilst the Plant Genetic Resources Center, field gene banks and medicinal plant gardens (where the primary goal is species and germplasm conservation), the Botanic and Zoological Gardens emphasise recreation and education .

In home gardens on the other hand, species are grown for their utility value. Nevertheless, they all play an ex- situ conservation role. In the past home gardens and hedges, particularly in rural areas, harboured large numbers of medicinal plants.

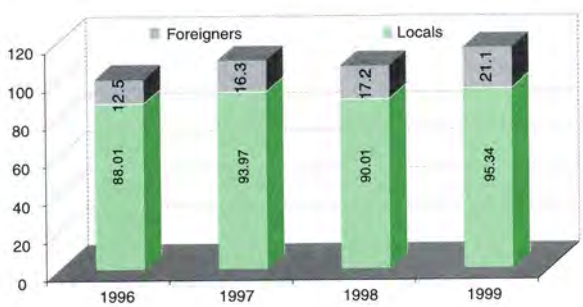
Owing to the decrease in land holding per family and the conversion of hedges to brick walls, these conservation sites are fast disappearing. Incentives to maintain such hedgerows are necessary.

Ex-Situ Conservation Centers

Live Collections	Preserved Collections
• Plant Genetic Resources Center • Botanic Gardens,Peradeniya,Heneratgoda and Hakgala • Home Gardens and Hedges	• Field Gene Banks (rice, agricultural plantation crops and arboreta) • Medicinal Plant Gardens • National Zoological Gardens • Pinnawala Elephant Orphanage • National Herbarium • National Museum

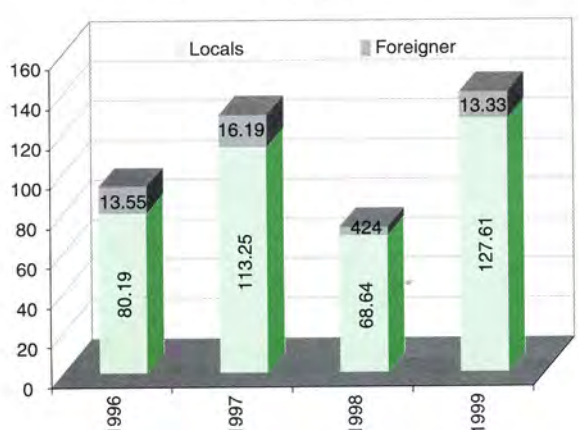
Visitation Levels of Locals and Foreigners

(i) Botanical Gardens, Peradeniya (x 10,000 visitors)



Source: Director Botanical Gardens

(ii) Plant Genetic Resources (x 10,000 visitors)



Source: Director Plant Genetic Recourses Center

3.4.5.3 Policies, Resource Inventories and Management Plans for Protected Areas

National policies relating to Biodiversity Conservation are included in the following:

i. National Conservation Strategy (1988).
ii. National Environmental Action Plan (1992-1995, 1995-1998 and 1998 - 2001)
iii. National Forestry Policy (1995)
iv. Forestry Sector Master Plan 1986, 1995
v. Biodiversity Conservation in Sri Lanka: A Framework for Action (1999)
vi. Wetlands Conservation Plan
vii. Coast Conservation Master Plan (Coastal 2000)
viii. National Wildlife Conservation Policy (2000)
ix. Pollution Abatement Strategy
x. Clean Air 2000 Action Plan
xi. Climate Change (Activities) Action Plan
xii. Cartegena Protocol on Biosafety (2000)

To implement these policies, the infrastructure of relevant departments and institutions is being improved, but requires sustained expansion. During the past decade, species diversity and other resources in protected areas have been inventorised and other biodiversity related projects funded through the following projects:

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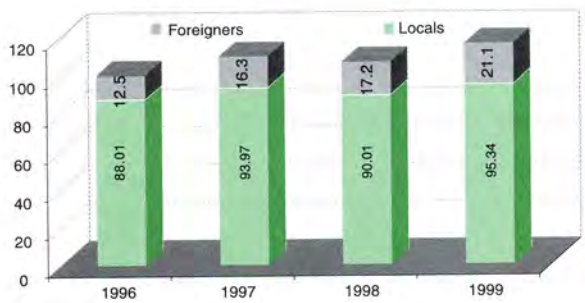
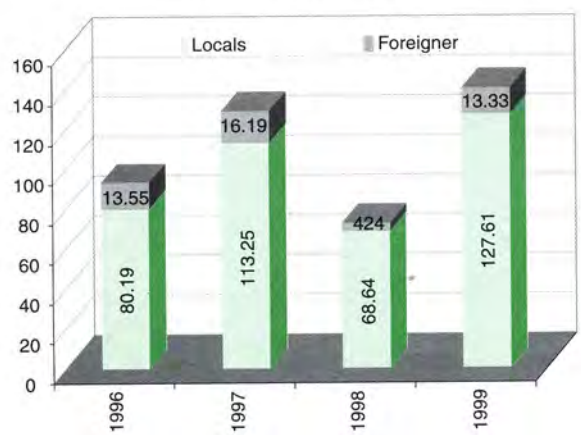


Source: Director Botanical Gardens

(ii) Plant Genetic Resources (x 10,000 visitors)



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- The FD, with support from IUCN, enumerated the diversity of plants, vertebrates, molluscs and butterflies under the National Conservation Review between 1991- 1996. This survey included 204 forests, each over 200 ha in extent, in different climatic zones. The ADB funded Forest Resources Management Project has 30 priority conservation forests for the completion of surveying and boundary demarcation in three forest complexes (Sinharaja, Peak Wilderness and other priority conservation forests). Management plans will be developed and implemented under this programme, with those for the Sinharaja Natural Heritage and Wilderness Area and 12 other conservation forests already completed. The programme includes attention to 74 other natural forests.
- The DWLC under the Global Environmental Facility (GEF) Programme has carried out resource inventories of 19 protected areas and drawn up management plans for 11 of them. Following this, a Wildlife and Protected Area Management Project funded by the ADB and GEF have been initiated.
- The Wetland Conservation Project, under the CEA has documented the biodiversity in 22 Wetland sites and drawn up management plans for 13 of them. This has been followed by an Integrated Management Project on the Muthurajawela and the Negombo Lagoon with community participation.
- The GEF Small Grants Programme, under Environment Action 1 Project of MoFE, has funded 84 projects related to biodiversity. They include forests and biodiversity encompassing community reforestation, protection of endangered and threatened species, cultivation and propagation of medicinal plants, community participation in conservation management, nature tourism, biodiversity management and habitat protection, preservation and enhancement of places of scenic beauty and prevention of fires. Under coastal and marine systems, 16 projects have been funded, including rehabilitation of coastal habitats, management of wetlands and conservation of small cetaceans and turtles.
- The Darwin Initiative of UK is currently funding an island wide survey of the molluscs, with in-depth studies in selected forests, viz., Knuckles and the Kanneliya-Dediyagala-Nakiyadeniya forest complex and Kottawa, in collaboration with the National Museum, Sri Lanka and the Natural History Museum, UK.

3.4.5.4 Laws and Regulations

There are about 80 laws and regulations relating to the environment. They relate directly or indirectly to biodiversity conservation. The most important of them are:

i. Land Development Act No.10 (1983) & Amendment Acts No.22 (1993), No.9 (1995), 20(1996).
ii. Crown Land Ordinance (1929).
iii. Fauna and Flora Protection Ordinance No.2 (1937) and Amendment Acts No. 44 (1964), No.1 (1970),No.49 (1993) and No.2 (1996).
iv. National Heritage and Wilderness Areas Act No. 3 (1988).
v. National Environment Act No.47 (1980) and Amendment Act No.56 (1988).
vi. National Aquatic Resources Research and Development Agency Act No. 54 (1981) and Amendment Act No.32 (1996).
vii. Fisheries and Aquatic Resources Act No. 2 (1996).
viii. Plant Protection Act No. 35 (1999).
ix. Animal Diseases Act.No. 59 (1992).
x. Coast Conservation Act No. 57 (1981) and Amendment Act No. 64 (1988).
xi. Forest Ordinance No. 3 (1945), Amendment Acts No. 13 (1966) and No. 13 (1988).
xii. Botanic Gardens Ordinance 3 (1961).
xiii. National Zoological Gardens Act 41 (1982).
xiv. Ayurveda Act No. 31 (1961) & Amendment Acts No.5 (1962) & No.9 (1969),No.7 (1977),No. 6 (1978).
xv. Soil Conservation Act (1951)

The international conventions signed by Sri Lanka relating to biodiversity conservation are:

i. International Plant Protection Convention,
ii. International Trade in Endangered Species of Wild Flora and Fauna (CITES),
iii. Protection of the World Cultural and Natural Heritage.
iv. Wetlands of International Importance (Ramsar).
v. Biological Diversity (CBD).
vi. Conservation of Migratory Species (Bonn Convention)
vii. Climate Change

Laws and regulations need to be more effectively enforced through a process of capacity building in the relevant agencies and the provision of required resources.

3.4.5.5 Other Responses

The National Environment Action Plan (NEAP) (1998-2001) has identified the loss of biodiversity as one of high priority requiring the development of policy and a regulatory framework for action. Consequently, "Biodiversity Conservation in Sri Lanka: A Framework for Action" was prepared and approved by the Cabinet of Ministers in April 1998. Eight CEPOMs have been set up to ensure that environmental concerns are reflected in all developmental programmes and to strengthen inter-sectoral co-ordination in environmental policy formulation, planning and implementation. The functions of the CEPOM on Biodiversity are to: -

i. review and analyse policy issues
ii. assess sectoral policies and development programmes and
iii. ensure compliance of environmental policies relating to biodiversity and eventually to internalise the NEAP recommendations within sectoral programmes.

The Environment Action I Project is supporting the implementation of NEAP through strengthening the institutions for improved management of environment, including biodiversity. MoFE has been mandated to develop recommendations for implementing a mechanism for access to genetic resources, benefit sharing and biosafety in biotechnology. A Task Force appointed by the MoFE has prepared draft laws for access to genetic resources. A technical committee has also been set up to formulate a code of ethics for bioprospecting and biosafety in biotechnology.

At the regional level, the preparation of Regional Biodiversity Action Plans has been initiated, beginning with the North Central Province. This is an important step to carry forward national level programmes on biodiversity.

3.4.5.6 Extension, Education and Awareness Programmes, NGOs

During the last two decades, the importance of community participation in biodiversity conservation has gained much recognition. Participatory forest management is being increasingly considered in the protection of conservation areas, particularly in buffer zone development activities.

NGOs, institutions and other agencies, as part of their annual activities, also organize education programmes related to biodiversity conservation. Biodiversity is now included as a subject in the secondary schools and tertiary education curricula in the country. In some protected areas a number of guides are available to show visitors around and share their experiences related to the reserve. However, considering the number of visitors to these parks, the number of guides is inadequate.

Both the electronic and printed media play an active role in biodiversity education. They highlight illegal activities and create awareness of the pressures on protected areas. In the recent past, the efforts of the Wildlife Heritage Trust have successfully brought out several well illustrated books introducing the species richness of Sri Lanka to the populace of the island.

3.4.5.7 Valuation of Biodiversity

The importance of the conservation of biodiversity was not realised in the past. Few understood and appreciated its value as a resource. Today efforts are being made to quantify the total value of resources in natural ecosystems, thereby justifying the need for their protection. This information is invaluable, especially when the conversion of these ecosystems to other land uses is being considered.

3.4.5.8 Gaps in Policy and Legislation

There are numerous policies, laws, action plans and institutions involved in the conservation of Sri Lanka's biodiversity. Although about 80 laws relate directly or indirectly to biodiversity conservation, implementation has been sluggish.

Conservation of biodiversity in the country is under the jurisdiction of many departments and ministries, viz., FD, DWLC, Coast Conservation Department (CCD), Agriculture, Ayurveda, Fisheries and Aquatic Resources, Botanic Gardens, Zoological Gardens, Ministries of Tourism and Science and Technology etc.

A proposal has been made to set up a Biodiversity Secretariat in the MoFE to co-ordinate, promote and facilitate the implementation of projects and programmes under the Biodiversity Conservation Action Plan.

Contradictory and conflicting areas in the existing policy and regulatory enactments need to be examined, reviewed and revised in the light of Biodiversity Conservation. Among them are the

- Laws relating to collection and export of live ornamental plants and animals
- Flora and Fauna Protection Ordinance and the Fisheries and Aquatic Resources Act in respect of the import and export of fish
- Acts relating to protected area management in the light of participatory management by all stakeholders
- Plant Protection Ordinance and the Animal Diseases Act in the light of micro-organisms, living modified organisms etc.

New policies should be developed to ensure sustainable use of the country's indigenous biological resources, conservation of biodiversity and the fair and equitable sharing of benefits that emerge from the use of genetic resources and indigenous knowledge.

3.4.6 Recommendations

- For effective protection of all conservation areas, boundary marking, zoning as well as capacity building of field staff and implementation of participatory management is imperative. A master map of the network of protected areas must be prepared, and the areas made inviolate to prevent further loss/reduction of the island's biodiverity. Impacts of large groups of visitors to these reserves need to be monitored and any adverse effects noted and remedied
- Conflicting and contradictory areas in policies and legislation need to be resolved
- For long-term sustainable management of biodiversity, a strong research capability must be developed, research priorities identified and implemented, data gathered, computerized and maintained over a period of time.
- The capability of researchers and the availability of research facilities, both on the field and at respective institutions, need improvement. Links with national and international expertise should be sought to strengthen and promote research. At the same time, benefits arising, if any, from international collaborative programmes must be equitably shared.
- Recreation, ecotourism and education on biodiversity and environment are fast expanding fields that need to be developed in a network of representative ecosystems in the country. The secondary school curriculum now compels all students to conduct an investigative project. For biology students, the outdoor laboratories of the country's ecosystems are a valuable resource yet to be tapped. Education centers nature trails and nature interpretation programmes at these sites need to be developed to realize the full potential of these ecosystems as outdoor laboratories.
- Degraded areas within reserves and buffer zones need to be rehabilitated and restored using indigenous species, to prevent further erosion of the genetic diversity in the reserves as well as to arrest the danger of conversion to other land uses.
- The present network of National MAB areas should be reviewed and revised to include the rich diversity of ecosystem types in Sri Lanka. The two international MAB reserves in the country too should be evaluated and a few other important forest areas such as the Peak Wilderness and the Knuckles should be recommended for International MAB status.
- Valuation of biodiversity for all the goods
- and services provided by different ecosystems needs to be carried out in order to fully appreciate their importance and justify their maintenance.
- The activities recommended in 3, 4 and 5 above should include local communities around protected areas, to draw on their traditions, their wealth of experience and indigenous knowledge in implementation.
- There has been much concern about bringing the Forest Department and the Department of Wildlife Conservation under one Ministry. Merging them also These activities will generate other opportunities of eco-friendly employment leading to poverty alleviation.
- together may not provide a solution to the problems faced in biodiversity conservation programmes. Further there are departments under other Ministries, which either directly or indirectly, are responsible for biodiversity conservation.
- What is required is close technical collaboration between the two departments at all levels, including field staff, as well as with other institutions like Irrigation, Agriculture Ayurveda and Meteorological Departments, Universities and Research Institution
- Each Department or Institution has its own strengths yet they have much to learn and benefit from each other. Understanding biodiversity conservation management, especially in natural ecosystems, is a complex subject and the technical expertise of the relevant departments must be harnessed towards this end. This will require working together in areas of common interest, joint field visits to examine problems at grass roots level and embarking on long-term projects.

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3.5 DEPLETION OF COASTAL RESOURCES

3.5.1 Introduction

The term "coastal resources" refers to resources, both living and non-living, found in the coastal region. The term "coastal area" in the context of the Coast Conservation Act, is defined as the Coastal Zone, a 2 km wide band of ocean and an adjoining strip of land extending 300 m inland. In the event a water body connected to the sea occurs the zone extends two kilometres inland from the mouth of the water body (Coast Conservation Act of 1981 and amendments; Ministry of Fisheries and Aquatic Resources (MoFAR) 1999). This definition is applicable for administrative purposes. In resource management, the coastal region can be considered to represent an area of transition where terrestrial and marine environments interact to form unique environmental conditions. The coastal region therefore includes inshore waters, inter-tidal areas and extensive tracts of contiguous land (Brown, 1997).

Economically, the coastal region is considered a distinctive area where development is influenced to a large extent by access to the sea (Savundranayagam et al, 1994).

For the purpose of this chapter, it would seem appropriate to use "coastal" in an environmentally and socially applicable context within a holistic and integrated perspective. It is well recognized that terrestrial and marine components of the coastal region are often closely connected through hydrologic linkages between upland catchments and coastal wetlands. A good example of these inter-linkages is seen where estuaries convert to lagoons with reduced water flow and/or increased silt load. The coastal region thus, could be considered to include an area of land or water where ecological processes of both land and marine environments are inter-linked, with a further linkage with human activities in the region.

The length of the Sri Lankan coastline is 1,585 km. from which the Exclusive Economic Zone (EEZ) extends 200 nautical miles. This is 6.7 times the country's land area occupying 437,400 sq. km. Coastal waters extends from the continental shelf to the other limits of the EEZ. The coastline and adjacent waters support highly productive marine ecosystems such as fringing coral reefs, shallow beds of coastal and estuarine seagrasses and an extensive system of 45 estuaries and 40 lagoons.

The coastal habitat covers 24% of land area and constitute a significant natural resource base

Maritime Territory of Sri Lanka

3.5.2 Pressure

From time immemorial, man has used both living and nonliving coastal resources. These are closely related to a natural resource base and, given time and the requisite conditions, living resources will regenerate themselves while non-living resources will continue to be generated within bounds imposed by ecosystem processes. Resource depletion results when pressure of exploitation exceeds generation rates. Excessive exploitation causes pressure directly on the resource

Extents of some Coastal Habitats

Estuaries and Lagoons	158, 017 ha
Mangroves	12,500 ha
Salt marshes	23,819 ha
Sand dunes	7,606 ha
Beaches	11,788 ha
Marsh	9,754 ha
Other water bodies	18,839 ha

Source: Coast Consrvation Department (CCD), 1992; Brown, 1997; Jinadasa, 1997; MoFE 1999

itself by its physical overuse and/or by indirectly exerting pressure on the resource-related ecosystem which disrupts resource generation rates. These can include a variety of causative factors such as pollution, destructive fishing gear and migration-related factors. Several factors contribute to coastal resource depletion through pressures brought about by increased consumer needs arising from residents in the coastal region or from geographically distant populations, either within the country or overseas. Diverse coastal resources are being subjected to extractive pressure (e.g. fish capture or sand mining) as well as non-extractive pressure (aesthetic enjoyment).

3.5.2.1 Population, Infrastructure and Industrial Expansion

Almost a third (32 %) of the country's population, two-thirds (65%) of the total urban population, two-thirds (67%) of the industrial facilities and over 80% of the tourist infrastructure accommodated within only one-, fourth (24%) of the island's land area having a coastal boundary (CCD, 1992; MoFE, 1999; CCD, 2000).

The increase of the coastal sector's contribution to the GDP from 35 % in 1983 to 40% (Savundranayagam et al, 1994, Brown, 1997) is indicative of increasing economic activity in the coastal area.

Projections estimate that coastal migration will continue to increase coastal population densities to 446 and even over 1,000 persons per sq. km (CCD, 1992; de Silva, 1997). The provision of necessary infrastructure to expanding coastal communities and industries will inevitably bring with it enhanced pressures on the dwindling coastal resources.

Source : SUK Ekaratne(2000)

Source : SUK Ekaratne, (2000)

3.5.2.2 Mangrove Ecosystems

An unmanaged industry can expand and create pressure on coastal resources eventually causing self-destruction as is well illustrated in the case of the tiger prawn export industry. Prawn farms were established in cleared ecologically sensitive mangrove areas in the northwest exerting tremendous pressure on mangroves and degrading associated lagoons and estuaries. It is estimated that 359.5 ha out of 1083 ha of shrimp ponds (Jayasinghe, 1995) and 400 to 500 ha of mangroves or mangrove associates (National Aquatic Resource and Development Agency (NARA), 1995) have been cleared. Pressure on water of lagoons and estuaries by the addition of chemicals and organic matter has resulted in changed water quality and depressed productivity of these waters. Waste from illicit liquor brewing has also exerted pressure on the productivity of these sensitive habitats

Pressure on mangroves and estuaries: causes of degradation /destruction;

- tiger prawn farming
- unsustainable fishing pollution
- timber felling and mangrove clearing
- land filling
- housing and infrastructure construction
- refuse dumping, including refuse from illicit breweries in mangrove hideouts

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- land filling
- housing and infrastructure construction
- refuse dumping, including refuse from illicit breweries in mangrove hideouts

3.5.2.3 Coral Reef Ecosystems

Source: SUK Ekaratne (1997)

Coral reefs are an important coastal resource that restrain coastal erosion and sustain coastal fisheries. Fringing reefs present around the island, also buffer shores from coastal erosion (CCD, 1997). Most of the known reefs, particularly readily accessible near-shore reefs, are damaged due to human pressure. Increases in organisms, such as tunicates and sponges, due to unknown causes, have also created pressure on reef ecosystem function (Bakus et al, 2000).

Pressure on Reefs: Causes of Coral Reef Degradation /Destruction

- coral mining
- dynamite fishing
- sedimentation
- pollution
- anchoring
- removal of reef organisms (for curios, aquarium trade)
- harbour construction
- Crown-of-thorns starfish
- corallivorous gastropods
- tunicates
- sponges
- algae species (Halimeda, Ulva)
- Bleaching (due to global warming) and subsequent coral death

Source : De Bruin, (1972); Rajasuriya and Rathnapriya, (1994); Ekaratne, (1990b, 1997c); De Silva and Rajasuriya, (1997); Abeysirigunawardana and Ekaratne, (2000b) Jinendradasa and Ekaratne, (2000)

Unprecedented coral bleaching of a widespread and severe nature that occurred in April 1998 was due to increase in sea surface temperatures (Ekaratne and Jinendradasa, 1998) associated with global warming or "el nino" events. High sediment and particulate matter loads as well as pollution from land-based sources, with loads of up to 3.2 kg day-1 m-2 (Ekaratne, 1997c) are other pressures affecting changes in the reef habitat. Possible over-collecting, inappropriate techniques (moxy net) of aquarium fish collecting, holding and transport in the export aquarium trade, damage and destroy the reef habitat. Coral mining, dynamite blast fishing, ghost nets from bottom nets, unplanned expansion of domestic and overseas tourism in coastal areas contribute to further destruction of the reef structure and reef habitat.

The marine capture fishery for non-edible aquarium exported species, harvests mainly fish and invertebrates from reef associated habitats. Relatively fewer numbers are harvested from estuarine areas, such as young groupers, and exported for culture as foodfish. Although the freshwater fish export industry cultures most of its exported fish, no marine species are cultured in Sri Lanka, with individuals being caught from the sea by divers using snorkel or SCUBA gear. They are collected mostly from inshore areas where corals occur, often by "moxy net" that damages the reef structure. Collected organisms are exported to over 25 countries including USA, Japan, United Kingdom, Holland, Germany, Singapore and Hong Kong. Recent trends in the marine trade have witnessed its expansion in species as well as in numbers, species having increased from 139 in 1985 (Wood, 1985) to over 200 (Ekaratne, 2000) and numbers from about 200,000 to almost 1,000,000 individuals. The pressure exerted by expansion of the fisheries for sea cucumbers (beche-de-mer) and chanks have seriously reduced their populations.

3.5.2.4 Protein Needs - Fisheries Expansion

The coastal and marine fishery is a major activity , which provides 65 % of animal protein in human diet. Until the mid 1950's, when traditional, non-mechanized crafts such as canoes with or without sails, wooden rafts and traditional fishing gear such as beach seine, hook and line, gill nets and traps were used, thetotal marine fish production was about 39,600 mt. The introduction of mechanisation, nylon nets and other technological advances have subjected this resource to increasing pressure. Initially increased but was

followed by a gradual decline. Continuing advances in fishing technology will increase the exploitation efficiency of sea fisheries. At present, the emphasis has shifted from coastal to deep-sea fisheries.

Source: SUK Ekaratne(1999)

Infrastructure development for the fishing industry such as the construction of harbours creates pressure on coastal ecosystems and coastal resources. Additional pressure is created by pollution from boats, anchor damage, unsustainable fisheries such as catching small sized fish, use of dynamite and other destructive practices.

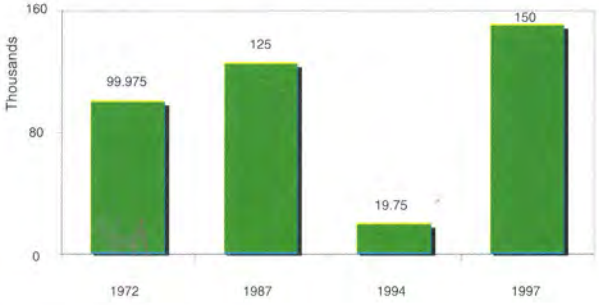
Increasing Pressure on Fish Stocks - the advances:

- Introduction of mechanized craft (late 1950's)
- use of nylon nets
- entry of private sector entrepreneurs (late 1970's)
- introduction of ice to freeze the catch at sea.

3.5.2.5 Aesthetic Needs - Tourism Expansion

The marketable "services" of coastal resources include the resource base for overseas and domestic tourism. Foreign tourist arrivals have risen at a rate of 33 % prior to the outbreak of ethnic strife in 1983. Although current rate has dropped to 15%, (Deheragoda and Tantrigama, 1997) increased visitation by domestic tourists, particularly to sites such as the Hikkaduwa Nature Reserve (the only marine Nature Reserve in Sri Lanka) has serious repercussions on the reef habitat. Increasing tourist arrivals will continue to be a source of pressure on coastal resources, particularly because coastal tourism is showing rapid growth worldwide (Brown, 1997). The changing

Coastal Fishery (catch mt)



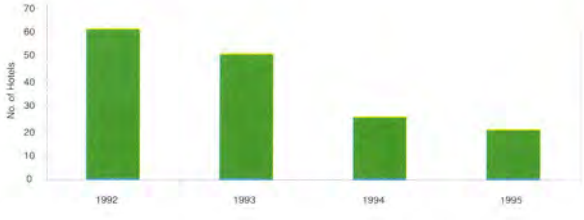
Source: MoFARD

pressure on coastal habitats through hotel construction, which was low over a 7-year period, is now seeing a gradual increase (data from CCD). While most coastal hotels discharge their used water and even sewage into the coastal waters causing pollution, social pressure is also created by communities through changed patterns of lifestyle. Reefs are damaged by careless snorkelling and diving by tourists. Increased sewage pits in the tourist areas of Beruwala, Bentota and Hikkaduwa have caused pollution of ground water and domestic wells.

3.5.2.5 Material Needs: Expansion of Non-Living Resource Exploitation

The collection of coastal non-living resources can gradually expand increasing pressure on the resource and instability of the habitat. For example, garnet sand mining creates instability of the shores at Hambantota, inland coral mining and seashell mining result in ground pits that alter the habitat profile. Sand mining carried out extensively affects beach nourishment and the integrity of the shoreline. Excessive sand mining from riverbeds would increase saline intrusion and riverbank collapse.

Hotel Approvals



Source: Ceylon Tourist Board Data

This issue is heavily addressed by plans for central waste treatment plans

Sand, a commonly used non-living resource, is exploited from the lower reaches of river basins and, to a lesser extent, from the shores. The volume of sand extracted has increased from 523,780 cubes in 1984 to 625,662 cubes in 1991(CCD, 1997). Sand mining from the offshore seabed has attracted discussion in recent times for purposes of infrastructure development such as highways. Since the adverse pressure of sand mining on the coastal ecosystem has been reported even in other countries, such activities need to be carefully re-examined so as not to exert undue pressure on coastal resources.

3.5.2.6 Infrastructure Expan sion, Waste Disposal, Shipping and Transport, Energy Utilisation, Coal Power Plants, Pollution and Water Quality

Considerable pressure is exerted on coastal water quality by ships operating on the major international shipping route off the southern and south western coast with an estimated annual traffic of over 5,000 tankers (NARESA, 1991). The routine dumping of engine oil into the water by fishing craft further pressurise water quality, food web functions and ecosystem integrity. Grounding of oil tankers, oil spills and leaks have occurred in the recent past, both from private and government-owned vessels/installations and create pressure on the coastal ecosystem processes. Mitigation measures need to be rapidly put in place in such an event to avoid degradation of coastal resources and ecosystem processes. Land filling occurs in several coastal wetlands for infrastructure facilities such as roads and housing. Even parts of the Mangrove Reserve of the National Aquatic Resources and Research Development Agency at Kadolkele in Negombo, which was a model mangrove system, has been encroached for housing.

The increasing trend in the country towards industrialisation cannot be supported by the available hydroelectric power generation capability. Unless power consumption is pruned down, which is unlikely in view of economic expansion, new power generation schemes such as coal power plants appear to be the only available option. The pressure on coastal resources exerted by such power plants has to be realistically assessed and mitigation measures adopted to prevent further degradation of coastal resources.

Industrialisation in the coastal zone also creates pressures on the natural ecosystem, e.g. the discharge of tannery industry waste. Pressure on coastal ecosystems from upland or upstream sources are common, such as the seepage of chemicals, including agrochemicals, into the sediment load that eventually reaches the coastal habitats through river run-off. Pollution can therefore arise from point and non-point sources.

3.5.2.8 Policy Disjunction and Operational Failure

The most important factor that generates continued pressure on coastal resource is the common impression that it is a "Common Property Resource."

Although the resource serves common ecological functions and benefits the community at large, no individual takes responsibility, or is accountable, for its well being. A resource with such characteristics cannot be managed merely by enacting laws and regulations. Awareness and participation of key stakeholders in its management are central to their sustainability. Ongoing initiatives such as the master plans, management plans and policy statements are noteworthy.

These initiatives need to be enhanced to develop operational mechanisms to realise their objectives. It is necessary to evolve an integrated, holistic approach to planning and plan implementation in inter-related sectors and interest groups. Factors such as overuse of agrochemicals, upstream pollution and depletion of coastal water quality by industrial and solid waste disposal result in pressures on coastal resources and could be avoided

3.5.3 State

Living renewable coastal resources in the form of marketable "goods" include fish, shark fin, shrimp, prawn, lobster, crab, bivalve, squid, cuttlefish, brine shrimp (Artemia) sea weed (Gracillaria, Sargassum), chank (Xancus pyrum), sea cucumber (beche-de-mer) and other invertebrates for the export aquarium trade. Seashells for lime production, plant material for handicrafts and agricultural produce are also marketable. In addition, there are a range of other species that are not marketed or are prohibited for sale, such as estuarine crocodiles, turtles, wading birds, sea birds and about 16 marine mammal species that include dolphins, whales and dugongs. The non-living coastal marketable goods comprise salt, graphite, limestone, clay, sand, feldspar, metal stone lime, kabook, brick, gem and ilmenite and other mineral sands. (Savundranayagam, 1994) The "services" from coastal resources include a wide range, from flood protection, nutrient flows, nursery and breeding grounds of species harvested for commercial and

ornamental purposes, tourism, turtle, whale and dolphin watching. Such services embrace aesthetics, support cultural traditions and ways of life of coastal communities and increasingly attract the domestic urban dweller as well as the overseas tourist.

Fishery related activities in the coastal region can be categorized into edible capture fisheries, aquarium capture fisheries and culture fisheries, the latter being mostly the tiger prawn/shrimp culture fishery. Although the emphasis of this section is on the depletion aspects of coastal resource, many resources may still remain unknown since cataloguing and inventorisation of resources, particularly those in the sea, have not been carried out comprehensively.

3.5.3.1 Capture Fisheries

The marine capture fishery of edible species is the major economic activity using biological resources of the coastal area. The coastal sea is the site of activity for the capture of finfish and shellfish (mostly for domestic consumption) as well as fish and invertebrates (for the marine ornamental export trade). Bays and other marine waters support the fishery of over 500 edible fish species (Jinadasa, 1997). Species ranging from small anchovies to coastal species of tuna, sharks, as well as semi-oceanic species such as spanish mackerel, skipjack and dolphin are caught. About 70% of coastal resources is composed of small pelagic fish like sardines, herrings, anchovies and mackerels and small demersal fish such as sciaenids and carrangids (Jinadasa, 1997). Brackish waters also contribute significantly to commercial fishery with a total production of about 4,000 mt per year. These fishery products include penaeid prawn (Penaeus monodon, Psemisulcatus, Metapenaeus dobsoni) mud crab (Scylla serrata) and brackish water species of fin fish (Mugil cephalus, Chanos chanos, Leiognathus sp and Etroplus suratensis) and bivalve molluscs (Meretrix casta, Crassostrea sp)

The capture fishery has risen to 206,300 mt in 1996 (NARA, 1998). The coastal catch that was 90,717 mt increased to 149,278 in 1987. During this period, offshore fishery contributed only 4,259 or 2.2 % of the total catch. Capture fishery increased to 174,500 mt in 1994 and fell back to 149,300 mt in 1996 but rose again to 152,750 mt in 1997 and to 171,950 mt in1999 (MoFARD data through MoFE). Estimates of the maximum annual sustainable yield range from 250,000 mt (MoFARD) to about 300,000 mt of fish. (Jinadasa, 1997). Based on exploitation levels and with the gill net fishery reaching maximum economic profit levels, a "precautionary approach" of not encouraging further expansion has been advocated (NARA, 1998b). A consensus has developed that the offshore fishery resource is under-exploited and that further expansion should target this resource. This is supported by the increasing contribution to total fishery landings made from offshore fishery. Offshore fishery which contributed 4,259 mt or 2.2 % to the total marine fishery in 1987, 7.1 % in 1990, expanded to around 25 % in 1995 and 1996 (NARA, 1998) and to 29 % in 1997. The estimate for the year 2000 is 84,400 mt.This compares with an estimated annual production from these sea areas that range from 90,000 mt (MoFARD, 1999) to about 100,000 mt (Jinadasa, 1997). Surveys have revealed that the deep-sea fish resource needs to be better exploited. A fleet of up to 160 tuna longliners can be sustainably maintained for this purpose (NARA, 1998), although scarcity of bait may pose problems for such a fleet size. These assessments are noteworthy and require regular updating. The estimated fish landings for 2000, as compared with MoFARD estimates (1999) for sustainable maximum yields per year would permit the harvesting of an additional 67,000 mt from coastal fisheries and about 6000 mt from off shore and deep sea fisheries. Further exploitation of these resources would be unsustainable.

Some invertebrate species in the edible marine capture fishery have been overexploited resulting in dwindling numbers. For example, the sea cucumber (beche-de-mer) fishery (entire production is exported to Singapore and Hong Kong) has a recorded history from 1808. Although 13 of the 70 species recorded in Sri Lanka are consumed in various parts of the world, only the dominant species (Holothuria scabra) was selectively harvested mainly by skin divers at depths of 2 to 16m with some caught as bye-catch of shrimp trawlers. The decline of the beche-de-mer fishery in the late eighties was attributed to indiscriminate over-harvesting. Unsubstantiated reports indicate that the several species that are now being over harvested. Export figures have recorded a decline from 272 mt in 1997 to 203 mt in 1998 (Joseph, 1993) Brown, 1997; data: MoFAR). Lobster and crab are also exported with 1998 export quantities being 164 mt and 486 mt, respectively. The harvesting of lobster could have harmful effects on wild stocks, as gravid lobsters as well as small-sized lobsters are regularly collected in spite of bans on such collection.

3.5.3.2 Other Resources

Seaweed is another living edible coastal resource with commercial potential. A trial project on seaweed culture, recently started in Kalpitiya lagoon is no longer in operation. Another edible coastal resource is coastal agricultural produce. Although not unique to coastal areas, maintenance of the integrity of agricultural land

will impact on social and ecological sustainability of coastal areas. Unsustainable land use practices for example, will lead to soil erosion and will in turn result in sedimentation of aquatic habitats. A loss of agricultural capacity will impact adversely as most coastal agricultural produce is marketed locally.

3.5.3.3 Shrimp Culture Fishery

The coastal culture fishery revolves around the farming of the tiger prawn/shrimp, P.monodon, begun in the late 1970's by the private sector. This industry grew at a rapid pace from the early 1980's. In 1996, there were 381 authorized and 600 unauthorized farms with a total area of about 2,500 ha. Shrimp production was 5,000 mt in 1995 (NARA, 1998).

The area under shrimp farming could be as much as 35 sq. km. or about 5 % of the 710 sq.km. of mangrove swamps, mud flats and salt marshes located along the coastline. Shrimp exports in 1998 were 5092 mt, almost doubling the 1997 figure of 2584 mt. All shrimp for culture are obtained from hatcheries and are grown in ponds in the farms concentrated along the north west coast. Most farms extract water from the Dutch Canal and also discharge effluents into the canal. (Corea et al, 1994, 1995, 1998) Although common property areas such as the mangrove-lagoon-estuarine areas are used for fishing of edible species, their conversion to prawn farms brings a greatly enhanced income, albeit to a few individuals outside the fishing community.

3.5.3.4 Marine Aquarium Fishery

In the marine capture aquarium fishery, 530 mt of organisms (both marine and freshwater) comprising approximately 200 species with a value of about Rs. 300 million was exported in 1996, which almost doubled to 1043 mt (with a value of Rs. 531 million) in 1998 (MoFARD; Ekaratne, 2000). All exported individuals are collected mostly from inshore areas where corals occur. The ecological status of the reef habitat (discussed below) would determine the sustainability of this industry. There are few pure limestone reefs in Sri Lanka, but corals grow on ancient sandstone largely along the west coast, or on gneiss or granite outcrops along the east coast (Salm, 1975, Wood, 1986).

Other non-edible living resources not exclusive to coastal areas such as raw material for handicraft products grow as a common property resource. However, to maintain the socio-cultural framework of coastal areas, sustainable use and common property issues of these resources need to be worked out.

3.5.3.5 Non-Living Resources

Non-living marketable coastal resources include mineral resources such as energy minerals, metallic minerals and non-metallic minerals. Among energy minerals, peat deposits that cannot as yet be economically used are estimated to be about 50 million tons. Radioactive minerals such as monazite, metallic ores such as iron ore (2.2 million tons), copper-magnetite deposits (4 million tons), mineral sands (4 million tons at Pulmoddai), ilmenite (3 million tons), rutile (6 million tons), zircon (4 million tons), high purity silica sands (6 million tons)as well as limestone, clays, deposits of inland coral and seashells, granite, granitic gneisses, marbles, quartzites and chamockites are also found in the coastal area. (Ranasinghe, 1997). Sand extraction is much - debated, since there are no firm estimates of sand generation and consequent availability. Government permits are required for sand mining but illegal extraction continues unabated.

3.5.4 Impact

Pressure generated by both human-induced activities and natural phenomena result in impacts on coastal resources, and brings about changes in the availability of coastal resources and their ecological functions (termed as goods and services or functions, respectively). Thus, impacts can have a direct effect on the related coastal resource and/or affect the resource generating process through effects on habitat and ecosystem quality.

Coastal resources may have a resilient capacity to withstand, or to rebound from, impacts by natural phenomena. This resilience may, however, be adversely affected by impacts arising from man-induced pressures. Any impact such as habitat loss (as in mangroves and coral reefs) would invariably impact negatively on biodiversity, at levels of genes, species and ecosystems. These impacts are more fully described below.

3.5.4.1 Coastal Erosion

Coastal erosion has been a problem over the years especially in the south, west and northwestern coasts. At certain locations, net erosion has been recorded up to 1 m per year. Accretion rates, on the other hand, have not exceeded 0.1 m per year, except in the northeast where the rate is 0.3 m per year. The average for the entire county is a net mean rate of erosion of 0.20 to 0.35 m per year (CCD, 1997). Apart from the impact on the shoreline, the financial impact brought about by the necessity for shoreline protection indicates, in economic terms, the gravity of the problem

and why factors that increase erosion need to be controlled. Protective measures to approximately 52 km of coastline by construction of revetments and groynes have cost Rs. 373 million since 1970; coast protection by stabilising 16 km of coast in Negombo and Moratuwa (1987 to 1989) have cost Rs. 322 million. The protection of threatened points along the main coastal road from Beruwala to Weligama (1990 to 1992) have cost Rs. 520 million (CCD, 1997). The expenditure incurred annually to mitigate shore erosion is at great cost to the national economy (Berg et al, 1998). Shoreward wave force in some areas in the southern coast has shown a statistically significant increase after post bleaching death of corals and the subsequent collapse of the reef structure. A 78% wave force increase has been recorded in January 1997 from 573.5 +- 43.50 to 1023.4 +- 36.70 in January 2001, as mg per hour of plaster dissolution (data from Jinendradasa, pers com). Coral destruction could thus lead to increased shore erosion and requires urgent remedial action and forward planning.

Causes of coastal erosion include damming of rivers, sand mining in beaches and rivers, destruction of protective reefs through coral mining, collection of coral rubble, removal of coastal vegetation, improperly sited shore protection structures and buildings and loss in river discharge due to upland water use (Ekaratne and Jinendradasa, 1997). Although evidence is not available for the causative factors, erosion remains a grim reality.

3.5.4.2 Mangroves and Associated Habitats

The destruction of mangroves and interruption of natural drainage has reduced flood - buffering capacity, with the result that the northwestern shrimp growing areas experienced massive flooding in 1997.

Source: SUK Ekaratne (1998)

The pressures on mangroves and associated lagoons and estuaries attributed to tiger prawn farming have affected ground water quality and resulted in increased salinisation of lands upstream of estuarine areas. Increased salinity in paddy lands have rendered them unproductive (Jayasinghe, 1995) or reduced rice yields by over 50 % (Wilks, 1995). During the period of the shrimp farm boom from 1983 to 1992, water quality in the Dutch canal deteriorated dramatically (Jayasinghe, 1995).

3.5.4.3 Coral Reef Ecosystem

Coral reefs are an important coastal resource that contain coastal erosion and sustain coastal fisheries. The mass coral bleaching that occurred in April 1998, resulted in extensive (around 80%) coral death followed by serious impacts on the reef ecosystem and in changes in fish populations, species composition, reef structure, biodiversity, succession and ecosystem functions. Even after two years of the bleaching, existing coral species have not recovered their reproductive capacities and there is little likelihood that reef ecosystems would regenerate and provide their normal services (Abeysirigunawardana and Ekaratne 2000a, 2000b; Jinendradasa and Ekaratne, 2000). Apart from bleaching, many other causes, outlined earlier, have resulted in most coral reefs being degraded or destroyed. Most of the known reefs, particularly readily accessible near-shore reefs, were degraded due to human-induced damage (Ekaratne, 1990b, 1997c). Possible over-collecting, improper and inappropriate techniques (moxy net) of collecting by the export aquarium trade damage or destroy the reef habitat. Coral mining and dynamite blast fishing, though banned, also goes on unabated in certain areas, impacting on reef quality and the integrity of reef structure.

3.5.4.3 Water Quality

Water quality is central to many economic and ecological coastal processes and activities. Deposits of agro-chemicals, sediment, industrial chemicals, sewage, domestic waste and plastics have increased in recent times. Tar balls arising from oil pollution is commonly seen on sandy beaches of the south and southwest coasts and could reduce the tourist potential of these beaches. Water quality studies carried out at a site in the southern coast over the last 5 years reveal an increase in particulate suspended sediment loads in these coastal waters with values increasing from 7.4 +- 1.30 in 1997 to 38.6 +- 11.92 in 2000 indicating a five fold increase (data from Jinendradasa pers com).

3.5.4.4 Silting

The construction of ill planned fishery harbours has produced almost continuous silting of harbours such as at Kirinda, whilst siltation has already commenced in the Hikkaduwa harbour, located adjacent to the Hikkaduwa Nature Reserve, which is now under construction. Fishery harbour construction will increase in terms of approved fisheries development plans. Lessons learnt from these experiences make it necessary to diligently carry out pre-construction impact assessment studies, to model, assess and plan for changed current patterns and silt loads that would be the inevitable results of construction.

3.5.4.5 Policy Framework

The inadequacies in integration of policy frameworks have resulted in unplanned and disjointed coastal activities. These include expansion of industries, building of hotels, over-visitation, etc at sensitive coastal locations such as the Hikkaduwa Nature Reserve. Ignoring the time-tested "Precautionary Principle" (where activities with damage potential are undertaken only after careful verification) is a perceived weakness of the planning process. Inappropriate training activities also reflect the need to develop a long-term integrated and effective approach to implement coastal management initiatives.

3.5.5. Response

Coastal resources are an integrated system and include a wide variety of habitats and ecosystems, each possessing important inherent features known as " functions". Such functions in coral reef ecosystems include high primary productivity giving rise to high rates of reef accretion as well as biophysical erosion resulting in the generation of calcareous sediment matter. In the case of mangroves and estuaries, functions include high primary and secondary production and enhancement of productivity by storage of organic sediments.

The functions of all coastal ecosystems include maintaining linkages between ecosystems for sustaining high production, food chain integrity, and migration routes for life history stages, etc. These generate the economically recognisable "goods" e.g. fish, shellfish, minerals, "services" such as recreation, flood control, storm and tidal wave defences, nursery grounds, nutrient flows, transportation and coastal tourism, to immediate or secondary communities. Therefore, an integrated holistic approach has to be adopted to achieve effective responses.

Sri Lanka has an impressive and comprehensive range of legal measures. The Coastal Zone Management Plan (CCD, 1997) is a well-thought out document that could be further expanded as new requirements surface. Some legal measures and plans require operational mechanisms for effective enforcement, and the removal of implementation gaps in the planning framework. Political will and change of anti-social attitudes,the provision increased resources to implementing authorities are matters requiringserious attention. Studies to elucidate changing ecosystem functions, resource inventorisation with regular updates and a planned and sustained long-term training strategy will facilitate the formulation of policy for sustainable utilisation and management of rapidly depleting coastal resources.

3.5.5.1 Range of Responses

A range of responses to meet the pressures and impacts on coastal resources include:

- Promulgation of laws (such as the Coast Conservation Act, Environment Acts, and regulations promulgated under the provisions of the Fisheries and Aquatic Resources Act)
- Preparation and implementation of National Coastal Zone Management Plans of 1990 and 1997
- Requirement for Environmental Impact Assessments and issue of permits by the Coast Conservation Department for major developmental activities in the coastal zone
- Banning of coral mining and the use of lime plaster on Government buildings
- Preparation and implementation of beach access plans, beach parks in narrow coastal stretches
- Outlawing unsustainable methods of fishing, such as "light course" and dynamite fishing, as well as the capture of gravid lobsters and undersized lobsters
- Increasing inputs into deep water oceanic fisheries so as not to increase pressure on coastal near-shore fishery resources
- Policy reviews to mobilize community participation
- Initiatives to mobilise local stakeholder ownership and stewardship (such as the community based shrimp fisheries management at Rekawa: (Davenport et al, 1999 and SAM project)
- Training and awareness programmes e.g. for customs officers
- Declaring protected areas for in-situ habitat conservation such as the Hikkaduwa Nature Reserve and the Bar Reef Sanctuary
- Inclusion of the concept of sustainable utilisation of coastal and marine resources in the 1999 six-

year development plan of the Ministry of Fisheries and Aquatic Resources Development

Programmes, studies and reviews encouraging a holistic and integrated approach such as the

- Coastal 2000 review

SAM : Special Area Management in Sri Lanka

Special Area Management can be defined as a collaborative, adaptive and flexible approach to planning resource management within a defined geographic area. It assumes that residents of a local community and the local government have both the incentives and the knowledge of the resources and resource-use problems to act collectively in ways that ensure that resources are used sustainably. A key aspect of the SAM approach is that even during planning, implementation of small projects can proceed.

Two areas have since 1991 been pilot testing sites for SAM planning: Rekawa and Hikkaduwa. The Coastal Resources Management Project (CRMP) has been acting as facilitator in the processes, through emphasis on data collection and analysis and education and organization of the local communities. The pilot areas are characterized by a varied set of management issues.

- Special Area Management Programme and the Wetlands Conservation Project
- Coral rehabilitation and research / training initiatives and programmes (such as projects done by Global Coral Reef Monitoring Network, Darwin Initiative, University of Colombo, NARA, University of Ruhuna, CCD)
- Development of oil contingency plan and the coastal sensitivity mapping project
- mprovement of the preparation and implementation of Special Area Management Plans for identified areas
- Preparation of zoning plans for identified coastal districts undertaken by the Marine Pollution Prevention Authority
- Community participatory, economically profitable lagoon fishery programmes (Davenport et al, 1999)
- Updating of ornamental fish export regulations
- Establishment of new agencies such as the National Aquaculture Development Authority (NAQDA), which would hopefully divert pressure from coastal non-sustainable activities to sustainable aquaculture activities
- The setting up of a Fauna and Flora Task Force by the Customs to apprehend illegal export/ import of organisms, which have so far included many coastal animals and animal parts
- Incorporating eco-tourism concerns in management plans

3.5.5.2 International Conventions

International Conventions to which Sri Lanka is a signatory include the Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES, 1973), the Convention on Biological Diversity (1992),

UN Convention on the Law of the Sea (UNCLOS), Conventions within the UNEP Regional Seas Programme, RAMSAR Convention, MARPOL Convention,

Convention for the Prevention of Marine Pollution from Land-based Sources (Paris Convention).

3.5.5.3 Legislation

The laws of particular relevance to coastal resources include

3.5.5.4 Recommendations

Recommendations for more meaningful management of coastal Resources;

- Develop capacity, strategies and procedures, including oil combating emergency procedures, for rapid pollution assessment, monitoring and containment for existing and potential pollutants
- Develop personnel, strategies and procedures for rapid coastal resource assessment and monitoring
- Develop procedures for regularly identifying permissible exploitation rates based on regular resource surveys and inventories, such as for edible and aquarium fisheries
- Develop management plans for sensitive and threatened coastal ecosystems and habitats as well as for presently-exploited and potentially-exploited living and non-living coastal resources, including the development of no-take areas. Also develop practice of periodic review of such plans.
- Develop indicators for assessing adequacy-inadequacy of effectiveness with regard to coastal resource management strategies

- Develop an interlinked coastal and marine Protected Area Network to include sensitive and threatened coastal ecosystems and habitats, specially in the seas which is not sufficiently developed at present
- Develop ex-situ and in-situ conservation and management procedures for threatened coastal resources
- Strengthen capacity for coastal impact assessment studies, coastal ecological studies and for identifying coastal biological resources through purpose-built bespoke courses
- Develop increased political will to allow implementation of laws
- Establish a nationally networked coastal/marine units in environment and marine-related agencies manned with personnel trained specifically for working in aquatic environments, which is lacking at present for coastal monitoring, surveillance and awareness creation
- Establish dynamic and flexible monitoring programmes
- Establish a programme to regularly identify sensitive and threatened coastal ecosystems and habitats
- Establish regular periodical reviews of policies, action plans, management strategies underpinned by resource survey and monitoring data
- Establish of a nationally-integrated politically-feasible holistic policy framework with regard to resources from near-shore to continental shelf areas
- Strengthen the Coast Guard services and train its personnel in coastal resource identification and management
- Strengthen monitoring, implementation and advisory capacities at local government level
- Mobilise greater stakeholder participation in resource management activities as well as in resource management planning and review
- Increase awareness in the multiple social layers with regard to resource sustainability and management concepts
- Place stronger emphasis in training younger persons and in quality recruitment procedures
- Integrate practices of different stakeholder agencies with responsibility for coastal resources and minimise/remove duplicated responsibilities to make specific agencies accountable for specific resources and management strategies
- Adopt precautionary practices where resource status is unknown

Legislation	Provisions
The Seashore Protection Ordinance, Gazette No.7710 (1929)	Bans the removal of coral, sand , etc
The Fauna and Flora Protection Ordinance, Gazette No.8675 (1940) and subsequent Amendments such as the Amendment Act, No 49 (1993)	Protects threatened and endangered wildlife including sea turtles and their nesting habitats. The Hikkaduwa Nature Reserve was declared on 14.8.1998 under this Act
The Fisheries Ordinance, Gazette No.12304 (1961)	Bans the use of destructive fishing gear and supports sustainable fishing activities; related regulations under Section 33 bans the possession of lobsters with eggs.
The Fisheries and Aquatic Resources Act, No 2 (1996)	
Adoption of the Coastal Zone Management Plan by Parliament in 1991	Transforms common-property open access fisheries into a managed industry, with a licensing system of all fishing operations and provisions for establishing "committees" of stakeholders, recognising a participatory approach.
The Tourist Development Act No.14 (1968)	Regulates services and prevents indiscriminate and unplanned development in resort areas.
The Natural Heritage and Wilderness Act (1980) amended in 1988	Requires Environmental Impact Assessments and licenses for industries, which may produce air, water and/or land pollution.

The National Aquatic Resources Research and Development Agency (NARA) Act No. 54 (1981)	Established NARA to bring about the conservation of aquatic resources in aquatic habitats including coastal and offshore areas, as well as to undertake research, disseminate information and provide advisory and consultancy services
The Coast Conservation (CCD) Act No.57 (1981)	Mandated CCD to develop a Coastal Zone Management Plan, regulate and control activities within the Coastal Zone, and formulate and execute coast conservation projects. It defined Coastal Zones to include portions of lagoons, estuaries and rivers. It also established uniform procedures for permit applications without distinction between development activities undertaken by private and state sectors. Among other provisos, this legislation encouraged collaboration among various government agencies involved in research and development activities within the Coastal Zone, specified penalties for violation of the law, and authorized the Director of CCD to demolish unauthorized structures. It also made possible the establishment of horizontal links between the relevant legislation.
Coast Conservation Amendment Act No. 64 of 1988	Empowers the Director of CCD to delegate powers, duties and functions to Government Agents or public officers of any administrative district, which contains a portion of the Coastal Zone. It bans the mining, collection, possession, storage, burning and transportation of coral, and the possession of limestone kilns. It authorises the demolition of kilns and the seizure of boats engaged in illegal activities within the Coastal Zone. Importantly, it grants the public the right to use any beach.
The Forest Ordinance No.3 (1945) Amendment No.13 (1966) and Act No.13 (1988)	Provides for the issue of permits for the harvesting, possession, sale and transportation of timber and provides for the prosecution of offenders. This law is of relevance to mangroves and their harvesting.
The Marine Pollution Prevention Act No.59 (1981)	Authorises the Marine Pollution Prevention Authority to prevent, reduce, and control pollution in Sri Lankan waters.
The Specified Tourist Services Code (1984)	Provides for the registration and licensing of all tourism-related establishments as well as enabling their classification
The National Environmental Act No.47 (1980) and Amendment No.56 (1988)	Establishes the Central Environment Authority (CEA) and provides for the protection of the environment against environmental degradation and the prevention and control of pollution. The Amendment provides greater environmental quality control including the EIA and EPL

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Part IV

Summary of Recommendations

PART FOUR : THE WAY FORWARD (SUMMARY OF RECOMMENDATIONS)

4.1 Introduction

Sri Lanka's environment is under increasing pressure from demands of its large population. The state of environment remains comparatively healthy but is under severe threat.

The five issues addressed in this SOE Report have been identified as the most critical environmental problems facing the country.
However, there are other environmental issues that are being addressed by the authorities but will require sustained attention e.g. air pollution by industrial and vehicular emissions, industrial pollution, depletion of forest cover, flooding and landslides due to unplanned reclamation of lands.

The dominant pressures affecting the state of the environment are the high population, and its high density, the rising standard of living that leads to greater consumption of resources and lack of employment opportunities in non-resource based fields.

Successive governments have taken steps to mitigate these impacts with remarkable success, especially in reducing population growth from 2.8% in the 1950s to the current rate of 1.1%. The policies and programmes of natural resource management however, have not experienced equal success.

Although the country has enacted comprehensive environmental laws, their enforcement is observed to be poor. The need arises for the integration of environment as an
important component of development planning and the effective implementation of such plans to achieve sustainable development. The alleviation of poverty, provision of employment opportunities and strict enforcement of existing regulations will prevent the environment from further degradation.

Greater public awareness, the commitment and will of decision makers and implementers are a sine quo non reaching the goals of sustainable development.This section focuses on a set of recommendations proposed to mitigate the major environmental problems faced by the country.

The main recommendations are presented under the subheadings, which are identified as the positive state of the five critical environmental problems included in this SOE Report.

4.2 Land Improvement and Conservation

The up country and mid country are especially prone to large-scale erosion due to the expansion of human settlements and the absence of appropriate soil conservation practices.

- Successive governments have used land resources to provide employment to the rural population, including alienation of environmentally sensitive lands, some of which have been subject to encroachment.
- Special attention needs to be given to the provision of alternate avenues of employment, particularly where natural resources are under threat.
- It is important to clearly demarcate the geographic areas suitable for different development purposes for the entire country. This requires the preparation of a sound Project coordinated by the Ministry of Irrigation and Water Resources is a good example of strategic planning in landuse. It plans to identify the most suitable areas in the country for intensive paddy cultivation. Marginal areas with low productivity in other parts of the country can then be converted to alternate and better uses.
- Forest depletion, which causes soil erosion, is partly due to poverty but largely determined by vested commercial interests. In order to reduce the demand for timber, research should be initiated to develop alternate materials for manufacture of furniture, house construction etc.
- The real cost of erosion, both on-site and off-site, is not adequately appreciated by decision-makers. The subject of resource economics, which is relevant to natural resource management, needs to be developed and practiced in policy analysis and planning.
- The relationship between different classes of land use and soil erosion has not been fully established. More research studies are needed in this field.
- New techniques and interventions are needed to arrest soil erosion in agricultural lands. New cropping systems have to be developed and the use of proven techniques such as SALT has to be expanded.

- Macro economic policy formulation should take into account the impact of land degradation and soil erosion on the national economy.
- The establishment of a central database with easy access, and facilities such as a website is essential.
- The enormous potential for nature based tourism in the country should be made use of as a means of alternative source of employment for the community which will consequently help the natural environment

4.3 Waste Management

Disposal of solid and liquid waste is primarily an urban problem. However, with the development of urban growth centers, the problem will become acute in the future. Open dumping is the main form of disposal with its attendant problems.

- Municipal solid waste comprises of 80% organic waste where incineration is not cost effective. Alternate disposal methods such as sanitary landfills should be developed.
- Assistance by way of training and technology for disposal of hazardous waste should be obtained from international agencies.
- Sharing of information and the establishment of a networking arrangement on the generation and transboundary movements of hazardous waste is required.
- A special facility is needed for the disposal of clinical waste, which at present is disposed along with domestic waste.
- Steps should be taken to reduce waste generation and to encourage recycling at domestic point sources.
- Local authorities should be provided with resources for collection and disposal of waste and required training and skill development.
- Recycling and reuse of waste and composting of biodegradable waste should be encouraged on commercial basis

4.4 Improvement of Water Quality

Land clearing and deforestation have resulted in sedimentation and destabilised seasonal water flows in rivers. Urbanisation and industrialisation have caused the pollution of urban waterways while intense use of agro-chemicals and the discharge of domestic and industrial waste has polluted rural waterways.

- Research on bioaccumulation of pesticides in the food web is an urgent need. Such research findings should be appropriately incorporated in food policies and publicity programs
- The use of agro chemicals for agriculture should be discouraged and organic farming with bio-control of pests and use of natural fertilisers encouraged
- Research on eutrophication and algae blooming in major reservoirs is an urgent need. Collaboration in this field with South Asian and other Research Institutes is recommended.
- Research conducted in other countries on improved pit latrines and on nitrates in water need to be shared through bilateral research exchanges.
- The establishment of industrial parks with central treatment plants and the adoption of clean technology are required. As a first step, all high polluting industries should be located in industrial parks.
- Improved sewerage systems initially in large urban areas is an urgent requirement.
- With the fast decline of water resources it is essential to develop strategies for sustainable water use.

4.5 Conservation of BioDiversity

Sri Lanka is rich in biodiversity but the species, genetic and eco-system biodiversity are under severe threat due to clearing of forests, expansion of settlements and other socio-economic pressures. Sri Lanka is identified as a 'hot spot' by the IUCN

Increase of population, lack of employment opportunities and poverty compel the rural population to utilize natural resources for sustenance. Commercial interests also contribute towards loss of biodiversity.

- Special programmes for selected eco-systems which have been internationally recognized such as Sinharaja, Hurulu forest Reserve, Western Ghats and Bundala need to be developed on a priority basis.
- The quality of inland aquatic systems has deteriorated due to the influx of agro chemicals, effluent discharges and invasion of exotic species. Regional and global co-operation in research and development for protecting inland aquatic systems is a priority need.
- The number of elephants killed per year indicates the increasing human - elephant conflict. Innovative approaches are needed to resolve this problem and the experience of other countries

will be useful to prevent the extinction of the largest mammal species.

- Over 480 flowering plant species, 90 fern species, 75% of endemic species in each of the vertebrate groups and 50% - 100% of endemic invertebrate groups are under threat. International co-operation is needed to conserve these species.
- There are clear indications of genetic erosion. The current gene bank facility established through bilateral assistance is primarily confined to agricultural crop species. International co-operation is needed to expand this facility to plant and animal species.
- The removal of ornamental fish and plants from nature resources poses a threat to these species. Strict enforcement of related international conventions and existing laws is essential.
- Protected areas under the Forest Department and the Department of Wild Life Conservation established with government and international funding have helped to conserve biodiversity. The buffer zone management is gaining acceptance and needs further support. Ensuring effective management of these projects is vital.
- Efficient management of Wild Life Conservation and Management Projects will result in long standing benefits to this sector.
- Inventorizing some aspects of biodiversity of the Island is being carried out at present by IUCN and GEF. Inventories are needed to cover other aspects of biodiversity in order to facilitate continuous monitoring.
- The MoFE should continue to take the lead role in coordinating biodiversity conservation programs with relevant local and international agencies.

4.6 Development of Coastal Resources

Many coastal ecosystems are under threat with consequent adverse impacts on the coastal ecology as well as the economy of the country. Coastal degradation will have far reaching implications for Sri Lanka as an island nation.

Steps need to be taken to regularize sea front constructions and prevent the destruction of coastal ecosystem mangroves, coral reefs and sand dunes

- Discharge of untreated organic industrial and agricultural waste into water bodies should be arrested.
- Destructive fishing methods such as gill net fishing needs to be discouraged.
- The exploitation of living renewable coastal resources including fish, prawns, lobsters, other invertebrates and sea weed as well as non-living resources such as limestone, graphite, clay and sand should be controlled with due consideration to their resource base
- Overexploitation of non-edible aquarium organisms is evidenced by the decline in the number of species. Steps should be taken to control such activities.
- Excessive sand mining must be regulated and confined only to specific locations.
- Over-visitation of diver sites, snorkel sites, mangroves, dumping of solid waste, discharge of untreated sewage in the coastal zone must be prevented.
- Coral mining, boat riding on living corals and anchoring of boats and use of dynamite for fishing must be arrested to prevent the destruction of coral reefs.
- Clearing of mangroves and associated lagoons and estuaries for prawn farming and shrimp ponds should be banned.
- The CCD should modify its plans from time to time and coordinate their implementation with relevant agencies in a participatory and consultative process.
- Strict enforcement of coast conservation laws is essential. CCD should be strengthened for this purpose.
- The development of tourism in coastal areas should be based on long term strategic planning for specific geographical areas.
- People living in coastal reservations (beach and set back areas) should be relocated and further encroachments prevented.
- Narrow coastal stretches should be acquired and maintained as scenic areas.

4.7 General Recommendations

Although Sri Lanka faces many environmental challenges, the country has several advantages in its literate population and the awareness of the community on the need for a clean environment. The following are some of the key recommendations that would help remedy the environmental issues:

- Enforcement of environmental laws must be strengthened. All enforcement agencies and the Police should be provided with required training and resources necessary to perform their duties without fear or favour, free from external pressures
- The Ministry of Forestry and Environment should continue to spearhead environmental management

programmes and strategies, and coordinate with relevant agencies, both public and private, for the development and implementation of sustainable development plans

- It is imperative to maintain the correct balance between the protection of the environment and the economic development of the country through appropriate planning processes.
- It is essential to integrate the environmental dimension into all sectors as an integral component of development planning. Key sectors need support to develop sustainable action plans
- With a diminishing land- man ratio, more people need to be weaned away from land-centered activity and drawn into expanded industrial and service sectors. Increased employment opportunities in these sectors will reduce the stress on natural resources.
- Water is fast becoming a scarce resource and it will not be possible to continue to set apart 80% of its usage for unprofitable cultivation. The Government cannot afford to play the role of ' provider' but should relegate itself to the role of 'facilitator' in the water sector. Communities need to play a positive and participatory role in obtaining their water requirements through available sources including the private sector.

A central regulatory mechanism with user representation can allocate water resources for competing needs, keeping in mind both economic and equity considerations.

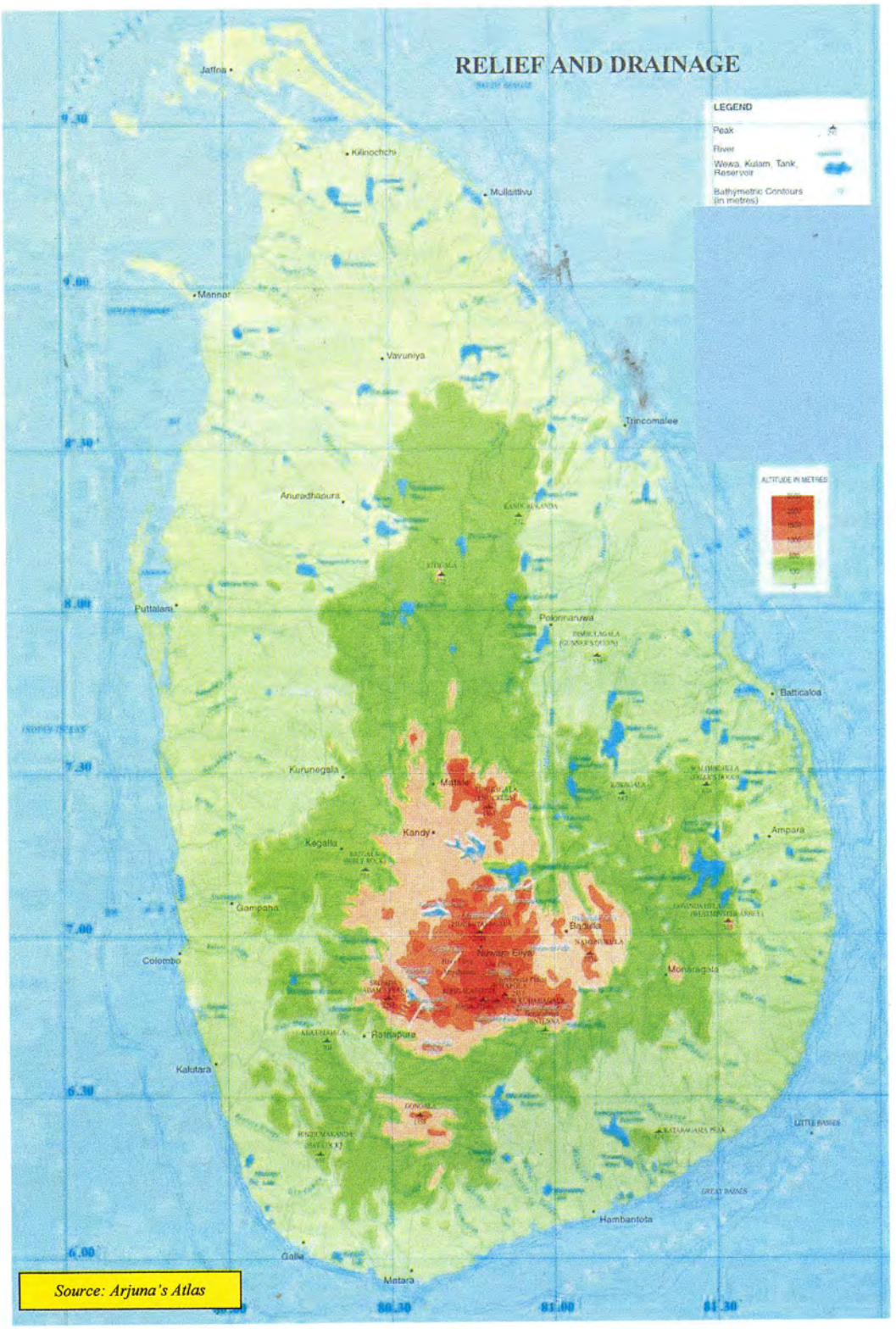
- The liberalization of trade can adversely impact on natural resources as environmentally sensitive lands can be cleared for cultivation of food and commercial crops.
- The main water bodies around the city of Colombo are highly polluted. The Kelani River, polluted both by industrial and domestic waste, supplies drinking water to Colombo, A 'Kelani River Action Plan' developed on the lines of ' Ganga Action Plan' of India will provide an excellent opportunity for bilateral co-operation between India and Sri Lanka
- Biotechnology will make great strides in the future and countries like Sri Lanka should take note of these developments and not permit its own biological assets to be exploited. Bio-technologically developed plant organisms and foods can greatly assist development in many ways including increase in food production.

However, the country should be alive to attendant problems. 'Bio-prospecting' can offer opportunities to rural communities to earn an income from unutilized and underutilized biological resources.

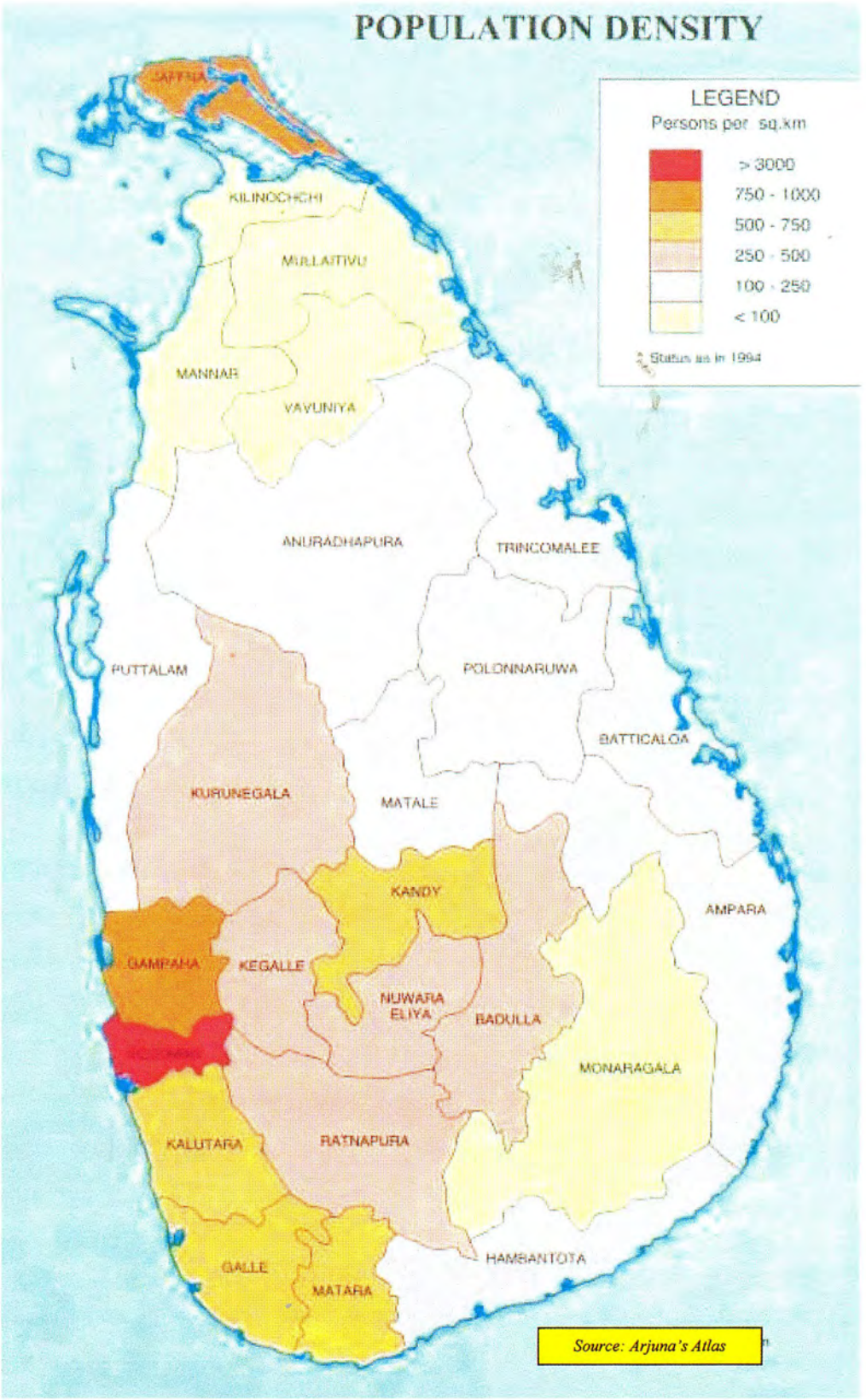
- Provision of urban infrastructure and public utilities to a growing urban population will be a major challenge. Development of peripheral towns and growth centers to absorb the outflow from the rural sector can be an important strategy.
- The concept of 'free' public utilities has to cease and beneficiaries will be called upon to pay for these services.
- Industrial growth will entail a higher degree of pollution of waterways, marshes, wetlands and the atmosphere and appropriate action to prevent such pollution is required.
- The 'polluter pays' principle needs to be introduced.

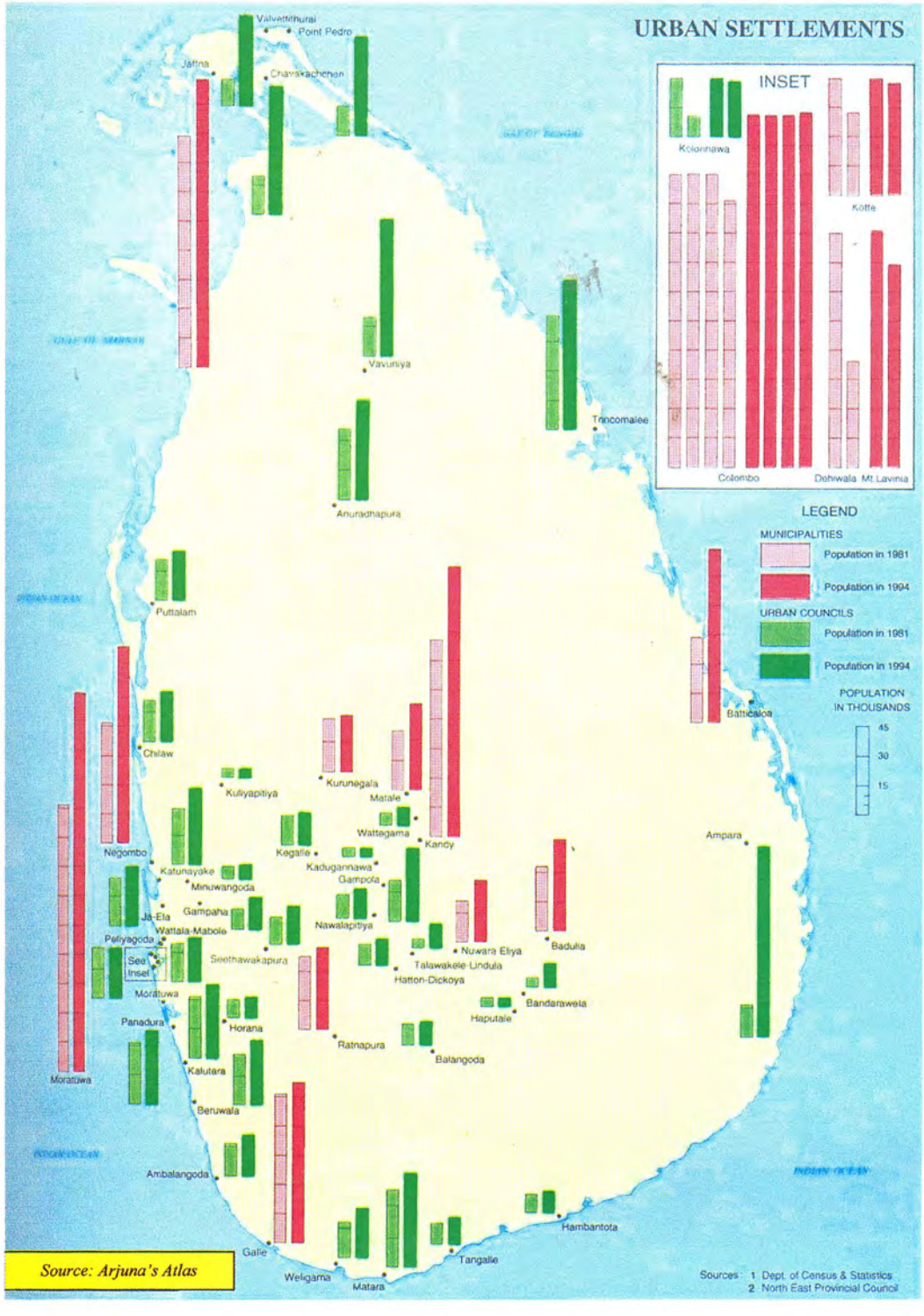
The biggest challenge facing Sri Lanka in the 21st Century is to maintain the right balance between environment and development. Emphasis should therefore be placed on the concept of 'environment management' as against "environment protection" in order to achieve the goal of sustainable development. The need of the hour is to harmonise the development needs of the people with minimum damage to environmental resources.

Part V Maps

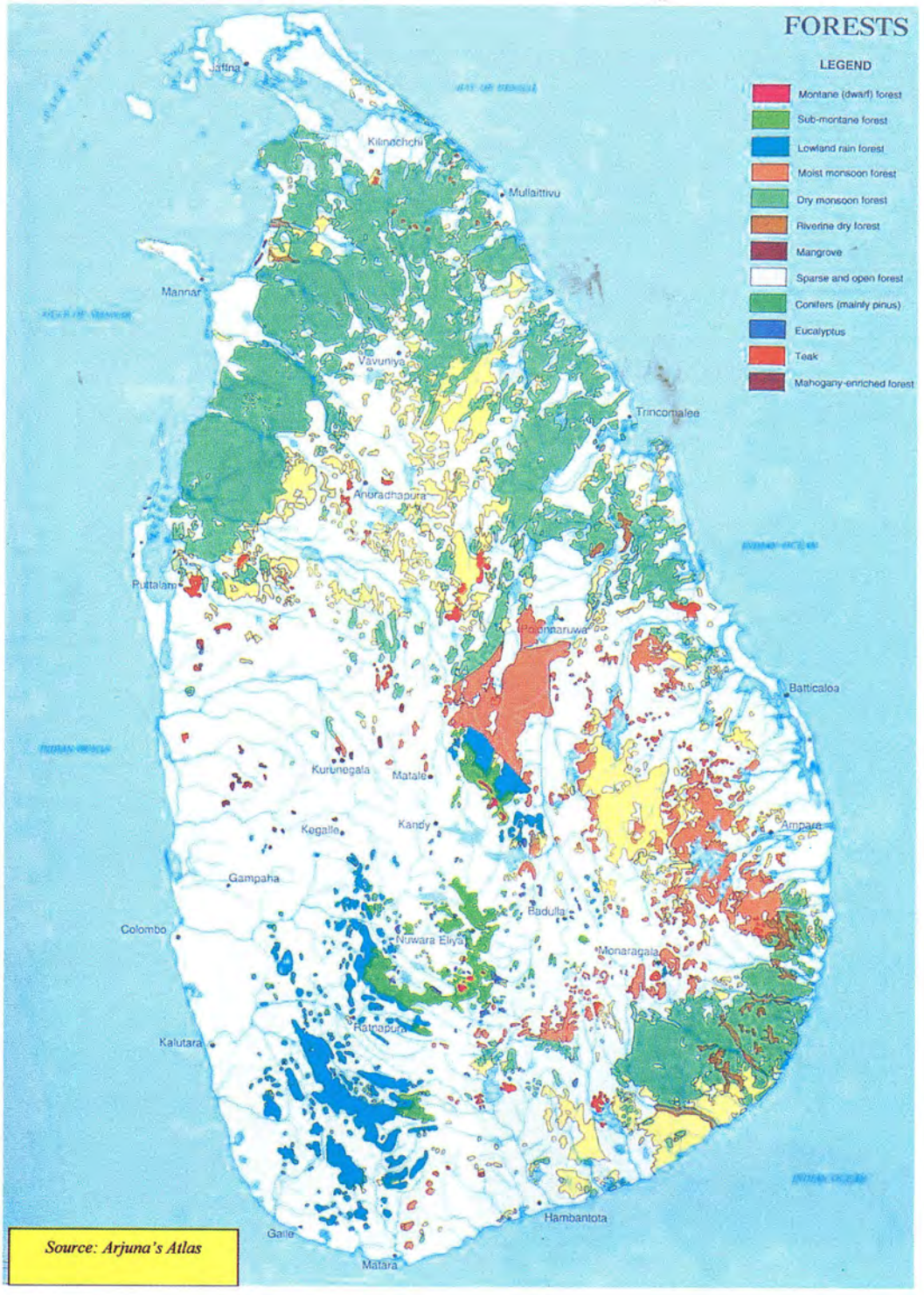


Source: Arjuna's Atlas


POPULATION DENSITY
LEGEND
Persons per sq.km
> 3000
750 - 1000
500 - 750
250 - 500
100 - 250
< 100
Status as in 1994
JAFFNA
KILINOCHCHI
MULLAITIVU
MANNAR
VAVUNIYA
ANURADHAPURA
TRINCOMALEE
PUTTALAM
POLONNARUWA
BATTICALOA
KURUNEGALA
MATALE
KANDY
AMPARA
GAMPAHA
KEGALLE
NUWARA ELIYA
BADULLA
MONARAGALA
KALUTARA
RATNAPURA
GALLE
MATARA
HAMBANTOTA
Source: Arjuna's Atlas


URBAN SETTLEMENTS
INSET
Kolonnawa
Kotte
Colombo
Dehiwala Mt. Lavinia
LEGEND
MUNICIPALITIES
Population in 1981
Population in 1994
URBAN COUNCILS
Population in 1981
Population in 1994
POPULATION IN THOUSANDS
45
30
15
Valvettithurai
Point Pedro
Jaffna
Chavakachchari
Vavuniya
Trincomalee
Anuradhapura
Puttalam
Chilaw
Batticaloa
Kuliyapitiya
Kurunegala
Matale
Wattegama
Kandy
Ampara
Negombo
Katunayake
Kegalle
Kadugannawa
Gampola
Minuwangoda
Gampaha
Ja-Ela
Wattala-Mabole
Nawalapitiya
Peliyagoda
Sea Inset
Seethawakapura
Nuwara Eliya
Badulla
Talawakele-Lindula
Hatton-Dickoya
Moratuwa
Bandarawela
Haputale
Panadura
Horana
Ratnapura
Balangoda
Kalutara
Beruwala
Ambalangoda
Hambantota
Galle
Tangalle
Weligama
Matara
Source: Arjuna's Atlas
Sources: 1 Dept. of Census & Statistics
2 North East Provincial Council

Source: Arjuna's Atlas



Source: Arjuna's Atlas

Part VI Annexes

ABBREVIATIONS

$\mu g/m^3$	microgram per cubic meter
10^0N	10^0 North
80^0E	80^0 East
avg.	average
C	Centigradae
CO_2	carbon dioxide
e.g.	for example
et al	and others
etc.	et cetera
govt.	Government
gwh	gigawatt hours
ha	hectares
i.e.	that is
kg	kilogram
kg/m^3	Kilogram for cubic meter
kJ	kilo Joules
km	kilometers
km^2	square kilometer
m	meter
m^3	cubic meters
mg/l	milligram per liter
mg/l	milligrams per liter
mm	millimeters
mt	metric tons
NO^3	Oxides of Nitrogen
NOx	oxides of nitrogen
pers.comm.	personal communication
pm	particulate matter
Rs.	Sri Lanka Rupees
SO_2	Sulphur dioxide
SOx	oxides of sulfur
sq km	square kilometer
t/ha/yr	tonnes per hectare per year
US$	United States Dollars
viz	namely
yr	year

ACRONYMS

AC	Air Conditioner
AD	Anaerobic Digestion
ADB	Asian Development Bank
AEA	Atomic Energy Authority of Sri Lanka
AIJ	Activities Implemented Jointly
AUSAID	Australian Agency for International Development
BOD	Bio-chemical oxygen demand
BR	Birth Rate
CBD	Convention on Biodiversity
CCD	Coast Conservation Department
CDM	Clean Development Mechanism
CEA	Central Environmental Authority
CEB	Ceylon Electricity Board
CEIP	Colombo Environment Improvement Project
CFC	Choloro Fluoro Carbon
CEIDP	Committee for the Integration of Environment and Development Policy
CEPOM	Committee for Environmental Policy and Management
CITES	Convention on International Trade in Endangered Species of Wild Flora and Fauna
CMC	Colombo Municipal Council
CMR	Colombo Metropolitan Region
COD	Chemical Oxygen Demand
CP	Central Province
CPHI	Chief Public Health Inspector
CUA	Colombo Urban Area
DEMA	Development, Environment and Management Associates
DMMC	Dehiwela - Mt Lavinia Municipal Council
DR	Death Rate
DWLC	Department of Wild Life Conservation
EAIP	Environment Action I Plan
EEZ	Exclusive Economic Zone
EHR	Erosion Hazard Rating
EIA	Environmental Impact Assessment
EPL	Environmental Protection Licence
ESCAP	Economic and Social Council for Asia and the Pacific
EPZ	Export Promotion Zone
FAO	Food and Agriculture Organisation
FD	Forest Department
GCA	Greater Colombo Area
GDP	Gross Domestic Product
GEF	Global Environmental Facility
GHG	Global greenhouse gases
GLASOD	Global Assessment of Degradation
GNP	Gross National Product
GTZ	German Technical Assistance Agency
HARTI	Hector Kobbekaduwa Agrarian Research and Training Institute
HDPE	High density polyethylene
IEE	Initial Environmental Examination
ISRIC	International Soil Research and Information Center
ITI	Industrial Technological Institute
IUCN	International Union for the Conservation of Nature
IWMI	International Water Management Institute

JICA	Japan International Cooperation Agency
LAs	Local Authorities
LDPE	Low density polyethylene
LUPPD	Land Use Policy Planning Division
MAB	Man and Biosphere
MASL	Mahaweli Authority of Sri Lanka
MC	Municipal Council
MoFAR	Ministry of Fisheries and Aquatic Resources
MoFARD	Ministry of Fisheries and Aquatic Resources Development
MoFE	Ministry of Forestry and Environment
MPI LTU	Ministry of Plan Implementation - La Trobe University
MPU	Montreal Protocol Unit (of MoFE)
MSW	Municipal Solid Waste
NARA	National Aquatic Resources Research and Development Agency
NARESA	Natural Resources, Energy and Science Authority (now National Science Foundation)
NBRO	National Building Research Organisation
NCP	North Central Province
NEA	National Environmental Act
NEAP	National Environmental Action Plan
NEDECO	Development Corporation of the Netherlands
NERD	National Engineering and Research Center
NEP	North Eastern Province
NGO	Non Governmental Organizations
NIMBY	Not In My Back Yard
NORAD	Norwegian Agency for Development Cooperation
NPK	Nitrogen phosphate potassium
NRMC	Natural Resources Management Center
NWP	North Western Province
NWSDB	National Water Supply and Drainage Board
ODS	Substances that deplete the ozone layer
PBB	Polybrominated biphenyl
PCB	Polychlorinated biphenyl
PCT	Polychlorinated thianthranes
PET	Polyethylene terephthalate
PHI	Public Health Inspector
PP	Polypropylene
PS	Pradeshiya Sabha
PSIR	Pressure- State- Impact- Response
RAPA	(FAO) Regional Office for Asia Pacific
SABP	Sabaragamuwa Province
SACEP	South Asia Co-operative Environment Programme
SALT	Sloping Agricultural Land Technology
SALT	Sloping Lands Agricultural Technology
SEA	Strategic Environmental Assessment
SELCO	Solar Electric Light Company
SHS	Solar Home Systems
SIDI	Secretariat for Infrastructure Development and Investment
SLBC	Sri Lanka Central Transport Board
SOE	State of Environment
SOER	State of Environment Report
SP	Southern Province
SWM	Solid Waste Management
TAMS	Tibbett, Abbott,Macarthy and Stratten
TRI	Tea Research Institute
UC	Urban Council

UDA	Urban Development Authority
UHCF	Unirrigated Highland Crop Farming
UMC	Upper Mahaweli Catchment
UNDP	United Nations Development Programmme
UNEP EAP.AP	Environment Assessment Programme for Asia and the Pacific of the United Nations Environment Programme
UNFCCC	United Nations Framework Convention on Climate Change
UP	Uva Province
USAID	United States Agency for International Development
VRR	Victoria-Randenigala-Rantembe
WHO	World Health Organisation
WP	Western Province

COMPONENTS OF THE NATIONAL SOE

Part I — **Executive summary**

Part II — **Sri Lanka's Environment An Overview**

- Background
  - Land Resources
  - Water Resources
  - Air
  - Forests and Wildlife
  - Coastal Resources
  - Biodiversity
  - Built Environment
- Linkages to Global Environment
  - Climate Change
  - Ozone Depletion
- International Obligations
- Policy, Legal and Institutional
- Coordinating Mechanism
- Education and Public Awareness
- Technological
- Priorities

Part III — **Priority issues**

- Land Degradation by Soil Erosion
- Waste Disposal
- Pollution of Inland Waters
- Loss of Biodiversity
- Depletion of Coastal Resources

Part IV — **Summary of Recommendations**

Part V — **Maps**

Part VI — **Annexes**

LIST OF PARTICIPANTS OF THE NATIONAL SOE TRAINING

Sindbad Hotel, Kalutara, Sri Lanka

5- 9 July 1999

Honorable Minister of Forestry and Environment, addressing the Participants at National SoE Training for Sri Lanka, 5-9 July 1999

The Secretary, Ministry of Forestry and Environment, addressing the Participants at National SoE Training for Sri Lanka, 5-9 July 1999

Mr. P. K. Kotta, Project Coordinator, SACEP, addressing the Participants at National SoE Training for Sri Lanka, 5-9 July 1999

The Participants and UNEP/EAP-AP representatives attended at National SoE Training for Sri Lanka, 5-9 July 1999

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100. Mr. Perera K. R. D. S., Statistician, Ministry of Forestry & Environment
101. Mr. Perera M. A. V., Commissioner, Colombo Municipal Council
102. Mr. Perera M. V., Chief Clark, Department of Import & Export Control
103. Dr. Pilapitiya Sumith, Senior Envt. Engineer, World Bank
104. Mr. Piyasena G., Director, Ministry of Fisheries & Aquatic Resources Development
105. Mr. Premaratne A., Deputy Manager, Dept. of Coast Conservation
106. Mr. Premasundara A. S., Asst. Director, Dept. of Animal Production & Health
107. Ms. Priyanthi W. M. M., Asst. Director, Dept. of Land use policy planning
108. Mr. Punchihewa Nimal, Chairman, Ceylon Fisheries Corporation
109. Mr. Purna Chandra Lall Rajbhandari UNEP RRC.AP Bangkok
110. Mr. Rajapakshe R. M. T., Deputy Director, Plant Genetic Resource Centre
111. Mr. Rajapakshe S. W., Controller, Dept. of Import & Export Control
112. Ms. Raman Lata, Development Alternatives India
113. Mr. Ramanayake R. S. M. P. B., Asst. Director, Mahaweli Authority
114. Dr. Ramanujan P., Secretary, Ministry of Livestock Development & Estate Infrastructure
115. Mr. Ranaviraja Tilak, Secretary, Ministry of Health
116. Mr. Ranawana Sanath, Project Specialist, ADB
117. Mr. Ranaweera R. A. A., Former Secretary, Ministry of Cultural & Religious Affairs
118. Mr. Rathnadeera W. K., Environmental Associate, Ministry of Forestry & Environment
119. Dr. Ratnasiri J., Former Coordinator, MPU, Ministry of Forestry & Environment
120. Mr. Ratnayake H. D., Deputy Director, Dept. of Wildlife Conservation.
121. Mrs. Sahanabadu M. J., Director General, National Transport Commission
122. Mr. Samarakkody R. P., NBRO
123. Dr. Samarakoon Jayampathi, Team Leader, IRMP
124. Mr. Samaranayake H. M. S., Chairman, Ceylon Tourist Board
125. Dr. Samaranayake R. A. D. B., Manager, CCD
126. Mr. Samarasekara Mahinda, Director General, Mahaweli Authority
127. Dr. Samarasinghe S. G., Director, HARTI
128. Mr. Samaratunga S. S., Asst. Director, CEA
129. Mr. Satharasinghe A. J., Statistician, Dept. of Census and Statistics
130. Mr. Seckler David, Director General, IWMI
131. Mr. Senaratne S. M. J., Director General, Custom Dept.
132. Mr. Seneviratne Asitha, Director, ministry of Constitutional Affairs & Industrial Development
133. Mr. Sibera A., Asst. Director, Ceylon Tourist Board
134. Mr. Silva Andrew De, Former Secretary, Ministry of Education & Higher Education
135. Dr. Silva Devaka De, University of Colombo
136. Dr. Silva E. I. L., Institute of Fundamental Studies
137. Dr. Silva Percy, Land Use Expert

138. Dr. Silva S. K. N. De, Chairman, NWS & DB
139. Mr. Silva T. K. N. P. De, Chairman, UDA
140. Mr. Sumithraarachchi D. B., Coordinator, EA1P, Ministry of Forestry & Environment
141. Mr. Surendra Shrestha, Regional Co-ordinator, UNEP
142. Mr. Suresh Kumar N., Research Officer, NARA
143. Mr. Susiripala H. L., Director, CEA
144. Prof. Tennakoon K., Director, Institute of Fundamental Studies
145. Mr. Tissera C. H. De, Director General, NBRO
146. Mrs. Weththasinghe C., National Building Research Organization
147. Mr. Weerasekara Danapala, Chairman, Marine Pollution Prevention Authority
148. Dr. Wickramanayake Nalin, Open University of Sri Lanka
149. Mr. Wickramarachchi S., Secretary, Ministry of Agriculture
150. Prof. Wickramasinghe Anoja, University of Peradeniya
151. Mrs Wijeratne. R., Science Officer, National Science Foundation
152. Mr. Wijesinghe Leslie, Former IUCN Country Representative
153. Mr. Wijesuriya L. T., Director General, Dept. of Irrigation
154. Mr. Wimalagunawardene H. A., Former Secretary, Ministry of Science & Technology
155. Mr. Yalegama S. S. B., Asst. Secretary, Ministry of Forestry & Environment
156. Ms. Yasaratne S. E., Country Representative, IUCN
157. Mr. Yoganathan K., Chairman, Water Resource Board
158. Mr. Pradyumna Kumar Kotta