STATE OF THE ENVIRONMENT


NEPAL



2001

MoPE/HMGN

ICIMOD

SACEP

NORAD
DIREKTORATET FOR UTVIKLINGSHJELP
NORWEGIAN AGENCY FOR DEVELOPMENT COOPERATION

UNEP

Nepal: State of the Environment 2001

UNEP

In collaboration with

MoPE/HMGN

SACEP

ICIMOD

NORAD
DIREKTORATET FOR UTVIKLINGSHJELP
NORWEGIAN AGENCY FOR DEVELOPMENT COOPERATION

Published by the United Nations Environment Programme

ISBN 92-807-2012-0

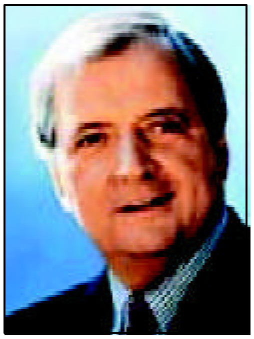
DISCLAIMER

Cover design
Purna Chandra Lall Rajbhandari and Ric Dennis A. Canullas
UNEP-RRC.AP

Layout
Dharma R. Maharjan
Sushil M. Joshi
ICIMOD Publications' Unit

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

Nepal: State of the Environment 2001



Foreword

Executive Director

UNEP

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 organisations, 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 Nepal is the first 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 Subregions (Laos and Vietnam). The Ministry of Population and Environment (MoPE), the national implementing agency in Nepal, has played a very crucial role in carrying out this participatory assessment process in soliciting input from various government sectoral agencies. Around 70 agencies and 150 individuals were involved in the process. With the substantive support from the International Centre for Integrated Mountain Development (ICIMOD), the designated national collaborating centre in Kathmandu, 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 key priority issues for the environment of Nepal have been identified through a consultative process and analysed following a 'pressure-state-impact-response' (PSIR) analytical framework. The same process will be followed by the other six countries, leading to the identification of their key environmental issues. These can then be addressed through action-based programmes in the next phase of the planning process.

The five key environmental issues identified for Nepal are forest depletion, soil degradation, solid waste management, water quality, and air pollution. The forest area is declining at an alarming rate due to high demand of fuelwood, the main source of fuel in the country, and forest clearance for land, leading to soil erosion, landslides, floods, and loss of biodiversity. Nepal's mountains and hills are inherently vulnerable to landslides and soil erosion which cause soil degradation, leading to a decline in crop production. Solid waste management problems have arisen because of the introduction of plastic materials and changing consumption patterns, especially in urban areas. Water quality, particularly in rivers and lakes near urban areas, is deteriorating due to unregulated discharge of domestic and industrial effluent, and the health of the nation's people is compromised by both inadequate waste-water treatment and insufficient supplies of potable water. Air quality, particularly in urban areas, is deteriorating due to increases in vehicular traffic and air-polluting industries, while rural inhabitants are vulnerable to respiratory diseases because of burning fuelwood in poorly ventilated houses.

This SoE assessment for Nepal 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 Nepal 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
26 March 2001

Foreword

Former Secretary
Ministry of Population and Environment, Nepal

Nepal is rich in various natural resources. Harnessing these resources can prove to be instrumental for the country's development. However, exploitation of these resources has to be carried out in a way that does not destroy the environment of the country. Thus, sustainable development and preservation of the natural environment have become challenges for today's Nepal.

Meeting such challenges requires evaluation and assessment of the status of the environment on a regular basis. A sound legal framework for management of the environment is equally important. There is no strong database on all aspects of the environment and natural resources and, as a result, no assessment and evaluation of the status of the environment could be carried out in a systematic and scientific manner. This report endeavours to close these gaps.

In May 1999 an agreement was formally signed between the United Nations Environment Programme / Environment Assessment Programme – Asia and Pacific (UNEP / EAP-AP, Bangkok) / South Asia Cooperative Environment Programme (SACEP–Colombo), and the Ministry of Population and Environment, His Majesty's Government of Nepal (MoPE – Nepal) / International Centre for Integrated Mountain Development (ICIMOD) for implementation of the project on 'Strengthening Environment Assessment and Monitoring Capabilities in Nepal – State of Environment Report'. The project aimed to augment the capacity of His Majesty's Government of Nepal to make accurate environmental assessments, improve decision-making for sustainable development, and establish a strong information network with a uniform data format.

This **Nepal: State of the Environment Report 2001**, highlighting the five key environmental priorities of Nepal (forest, soil, solid waste, water, and air) has been prepared at an appropriate time. These priority issues are genuine and very relevant to the present day context of environmental development in Nepal.

This report, prepared with the generous financial support of the United Nations Environment Programme (UNEP) and the Norwegian Agency for Cooperation and Development (NORAD), will serve as a valuable input and will help planners, policy-makers, and decision-makers to develop plans and formulate policies for the sustainable development of natural resources in Nepal without compromising the environment.

The Ministry is grateful to Mr. Surendra Shrestha, Director of UNEP-EAP, for bringing this project to Nepal. It extends its thanks to Dr. Gabriel Campbell, Director General, Dr. Binayak Bhadra, Director of Programmes, and Mr. Pramod Pradhan, former Head of ICIMOD-MENRIS, as well as Dr. Bandana Kayastha Pradhan, national consultant-SEAMCAP project, for their sincere endeavours in the successful implementation of this project and timely completion of the report. The contributions of Mr. Basanta Shrestha, the Acting Head of the MENRIS Division of ICIMOD, and Ms. Bidya Banmali towards completion of the project are also duly recognised. Appreciation is also given to Mr. Janak R. Joshi, Joint Secretary, Mr. P. Kunwar, Under Secretary, and Mr. B. K. Uprety, Ecologist of this Ministry for their contributions towards the successful completion of this project. Last, but not least, the work of all those who have given their support to the project is also sincerely acknowledged.

Dr. Govind Raj Bhatta
Former Secretary
Ministry of Population and Environment
Kathmandu
March 2001

Foreword

Director General
ICIMOD

The environment of Nepal and the Hindu Kush-Himalayan (HKH) Region, in which it holds a place of pride, is renowned for its beauty and benefits. The divine snow and forest-clad mountains attract pilgrims and tourists alike. The rivers provide power and water for hundreds of millions downstream.

But all is not well with Nepal's mountain environment. The towering ridges are holding in a brown cloud of pollution over South Asia. Many forest areas are disappearing. Water is becoming increasingly polluted. In short, this beautiful mountain environment is in danger – but to what extent and from exactly what sources? What is the real state of the environment in Nepal? This is the question addressed in this report.

A fundamental problem in determining the state of the environment and natural resources of Nepal and the countries in the Hindu Kush-Himalayan (HKH) region is that available data are scanty and scattered. The lack of adequate and aggregate data makes it difficult to evaluate the status of the environment of individual countries, let alone of the region as a whole. Poor data also make it difficult to build a sound legal foundation and support wise decision-making for sustainable development and conservation of the environment.

The types of environmental problems and their magnitude vary considerably among the countries in the HKH region. This report, entitled **Nepal: State of the Environment 2001**, profiles the key mountain environment issues of Nepal: forest, soil, solid waste, water, and air. It is anticipated that the information contained in this report will not only help to design policies and programmes for the environmental conservation of Nepal but will also provide a framework for environmental management that can be used as a guideline for other HKH countries.

The immediate objective of this project – Strengthening Environmental Assessment and Monitoring Capabilities in South Asia and the Greater Mekong Sub Region (SEAMCAP) – was to contribute to the preparation of the Nepal report, which will also feed into the preparation of the Decadal 2002 Global State of Environment Report. The goals of the project were to strengthen capacity and assist the government in establishing a strong information technology base for data processing, modelling, and analysis requirements to support assessment and reporting and to improve the basis for addressing important, emerging environmental problems.

The Ministry of Population and Environment (MoPE) was the national focal point for this project. ICIMOD has served as the collaborating and facilitating centre for completing this project and associated activities. It extends its gratitude to the MoPE and other government agencies for their cooperation in the successful completion of this project report. The project was also assisted by the United Nations Environment Programme (UNEP), the South Asia Cooperative Environment Programme (SACEP), and the Norwegian Agency for Cooperation and Development (NORAD).

Dr. Bandana Kayastha Pradhan, national consultant, SEAMCAP project, has been responsible for much of the successful preparation and production of this project report. ICIMOD extends its gratitude to her, as well as to Mr. Pramod S. S. Pradhan, former Head of MENRIS Division, for his full-hearted effort to make this project successful. The help of Mr. Basanta Shrestha, the current Head of MENRIS Division, is highly appreciated in carrying this project to its completion. Mr. Birendra Bajracharya, GIS Specialist, has helped not only in preparing maps but also in providing valuable comments and suggestions for the report. Similarly, Ms. Bidya Banmali has helped in various ways to complete the report. Other MENRIS staff members who assisted in the preparation of this report are Mr. Pradeep Mool, Mr. Sushil Pradhan, Mr. Sushil Pandey, Mr. Samjol Bajracharya, Mr. Govind Joshi, Mr. Anirudra Shrestha, Mr. Saishab Pradhan, Ms. Monika Moktan, Ms. Sheela Thapa, and Ms. Meghna Shrestha. Ms. Greta Rana is due special thanks for rearranging her work schedule and that of the Publications' Unit (Dr. A. Beatrice Murray, Mr. Dharma R. Maharjan, Mr. Sushil M. Joshi, and Mr. Asha K. Thaku) to prepare this report for printing on an extremely tight schedule. As the Secretary of MoPE, Dr. Govind R. Bhatta provided overall guidance and supervision as well as timely comments, suggestions, and encouragement for this report. The help provided by Mr. Janak R. Joshi, Mr. Purushottam Kunwar, Mr. Batu K. Uprety, and Mr. Chiranjibi Gautam of MoPE is also acknowledged and highly appreciated. In addition to these, sincere thanks are due to all those experts, reviewers, core groups, and contributors whose names and designations are given in full in the Annexes to this report.

ICIMOD is particularly grateful to Mr. Surendra Shrestha, Director of UNEP-EPA/AP, for his initiative and guiding hand in developing and carrying this project forward. Mr. Varun P. Shrestha, Former Secretary of MoPE, and Dr. Madhav Ghimire, Former Joint-Secretary of MoPE, are thanked for their role in bringing the project to ICIMOD. The project report is enriched by the comments and suggestions of Dr. Ananda Raj Joshi and Mr. Pradyumna K. Kotta of SACEP, and Mr. Choudhury R. C. Mohanty and Mr. Purna C. L. Rajbhandari of UNEP/EAP-AP. Finally, ICIMOD expresses its thanks to all contributors and reviewers representing various organisations in Kathmandu, Nepal, as well as the core group of participants at the SEAMCAP Meeting and its staff members who were involved in this project.

I am hopeful that the efforts of all these committed people will provide a richer, more accurate information base for conserving the endangered environment of Nepal and the mountains of the HKH and allow Nepal to participate effectively in the global environment agenda.

J. Gabriel Campbell
Director General
International Centre for Integrated Mountain Development
Kathmandu
March 2001

Acknowledgements

UNEP would like to thank the many individuals and institutions who have contributed to the preparaton of ***Nepal: State of the Environment 2001***. They included individuals in government departments, intergovernmental organisations, academic institutions, and voluntary organisations. A full list of contributors, reviewers, and participants of the national State of the Environment training and consultation are included in the Annexes. Special thanks are extended to the following institutions.

National Implementing Agency
Ministry of Population and Environment (MoPE), Nepal

National Collaborating Centre
International Centre for Integrated Mountain Development (ICIMOD), Nepal

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

SEAMCAP Project Facilitator
Raghunathan Rajamani

Project Leader at National Level
Bandana Kayastha Pradhan

Editors
Peter Edwards
Greta Rana
A. Beatrice Murray Shrestha

SEAMCAP Project Team

UNEP RRC.AP
Surendra Shrestha
Choudhury Rudra Charan Mohanty
May Ann Mamicpic-Bernardo
Mylvakanam Iyngararasan
Purna Chandra Lall Rajbhandari

SACEP
Ananda Raj Joshi
Pradyumna Kumar Kotta

Acronyms and Abbreviations

ADB	Asian Development Bank
AEPC	Alternative Energy Promotion Centre
AIC	Agricultural Inputs Corporation
AIT	Asian Institute of Technology
APP	Agricultural Prospective Plan
APROSC	Agricultural Projects Services Centre
ARI	acute respiratory infection
ASD	Agricultural Statistics Division
BHC	benzene hexachloride
BOD	biological oxygen demand
BOD_5	biological oxygen demand (5 days)
BPP	Biodiversity Profile Project
CBO	community-based organisation
CBS	Central Bureau of Statistics
CDG	Central Department of Geography
CDR	Central Development Region
CEDA	Centre for Economic Development and Administration
CFC-12	chloroflurocarbon
CITES	Convention on International Trade in Endangered Species of Wild Fauna and Flora
COD	chemical oxygen demand
DDC	district development committee
DFI	district forest inventory
DFRS	Department of Forest Research and Survey
DHM	Department of Hydrology and Meteorology
DHS	Department of Health Services
DMG	Department of Mines and Geology
DNPWC	Department of National Parks and Wildlife Conservation
DISCO	District Soil Conservation Office
DO	dissolved oxygen
DoA	Department of Agriculture
DoC	Department of Customs
DoF	Department of Forests
DoF	Department of Finance
DoHS	Department of Health Services
DoI	Department of Irrigation

DoR	Department of Roads
DPR	Department of Plant Resources
DPTC	Disaster Prevention Technical Centre
DSCWM	Department of Soil Conservation and Watershed Management
ECOS	Environmental Conservation through Education and Research
EDR	Eastern Development Region
EIA	environmental impact assessment
ENPHO	Environment and Public Health Organisation
ESPS	Environment Sector Programme Support
EPA	Environmental Protection Act
EPC	Environmental Protection Council
EPR	Environmental Protection Rule
EURO-1	European Standard One
FINNIDA	Finnish International Development Agency
FSD	Forest Survey Division
GDP	gross domestic product
GEO	Global Environment Outlook
GHG	greenhouse gas
GIS	geographic information systems
GLOF	glacial lake outburst flood
GTZ	German Agency for Technical Co-operation
GWRDP	Groundwater Resource Development Project
HC	hydrocarbon
HCFC	hydro-chlorofluorocarbon
HMG	His Majesty's Government
HMGN	His Majesty's Government of Nepal
HOPE	Hidden Opportunities for Productivity and Environment
HSD	high speed diesel
HSU	Hartridge smoke unit
HVS	high volume sampler
ICS	improved cooking stove
ICIMOD	International Centre for Integrated Mountain Development
IEC	information, education, and communication
INGO	international government organisation
IPCC	Intergovernmental Panel on Climate Change
ITTA	International Tropical Timber Agreement
IUCN	International Union for Conservation of Nature
JEC	Japan Environment Corporation
KMC	Kathmandu Metropolitan City
KVVECP	Kathmandu Valley Vehicular Emission Control Programme
LEADERS	Legal and Environmental Analysis and Development Research
LPG	liquefied petroleum gas
LRMP	Land Resources Mapping Project

LRTI	lower respiratory tract infection
LWK	live weight of killed animal
MENRIS	Mountain Environment and Natural Resources Information System
MFSC	Ministry of Forest and Soil Conservation
MHPP	Ministry of Housing and Physical Planning
MLD	Ministry of Local Development
MNR	Mountain Natural Resources
MoA	Ministry of Agriculture
MoE	Ministry of Education
MoF	Ministry of Finance
MoH	Ministry of Health
MoHA	Ministry of Home Affairs
MoI	Ministry of Industry
MoPE	Ministry of Population and Environment
MoWR	Ministry of Water Resources
MPFS	Master Plan for the Forestry Sector
MUAN	Municipal Association of Nepal
MWDR	Mid-Western Development Region
NAA	Nepal Agricultural Association
NARC	Nepal Agricultural Research Council
NARMSAP	Natural Resource Management Sector Assistance Programme
NBSM	Nepal Bureau of Standards and Metrology
NEA	Nepal Electricity Authority
NECG	Nepal Environment Conservation Group
NEPAP	Nepal Environmental Policy and Action Plan
NESS	Nepal Environmental and Scientific Services
NFI	National Forest Inventory
NGO	non-government organisation
NHDR	Nepal Human Development Report
NOC	Nepal Oil Corporation
NORAD	Norwegian Agency for Cooperation and Development
NPC	National Planning Commission
NSIC	Nepal Standard of Industrial Classification
NTFP	non-timber forest product
NTU	nephelometer turbidity unit
NVMES	Nepal Vehicular Mass Emission Standard
NWSC	Nepal Water Supply Corporation
ODS	ozone depleting substance
OPD	outpatients department
PAH	poly aromatic hydrocarbon
PARDYP	People and Resource Dynamics in Mountain Watersheds of the Hindu Kush-Himalayas
RWSSP	Rural Water Supply and Sewerage Project
SACEP	South Asia Co-operative Environment Programme
SEAMCAP	Strengthening Environmental Assessment and Monitoring Capabilities in South Asia and the Greater Mekong

SEI	Stockholm Environment Institute
SEI	significant environmental issues
SIDA	Swedish International Co-operative Development Agency
SoE	State of the Environment
SWMRMC	Solid Waste Management and Resource Mobilisation Centre
TDFB	Town Development Fund Board
TDN	total digestible nutrients
TDS	total dissolved solid
TFR	total fertility rate
TPC	Trade Promotion Centre
TSP	total suspended particulates
TSS	total suspended solids
TU	Tribhuvan University (Kathmandu)
UBC	University of British Columbia
UDLE	Urban Development Through Local Efforts
UNDP	United Nations Development Programme
UNEP/EAP-AP	United Nations Environment Programme/Environmental Assessment Programme for Asia and the Pacific
UNICEF	United Nations Children's Fund
URBAIR	Urban Air Quality Management Strategy in Asia
URTI	upper respiratory tract infection
USEPA	United States Environmental Protection Agency
VDC	village development committee
VOC	volatile organic matter
WDR	Western Development Region
WECS	Water and Energy Commission Secretariat
WHO	World Health Organisation

Symbols and Units

Symbol (Chemical)

As	arsenic
C	carbon
CH_4	methane
Cl^-	chloride ion
CO	carbon monoxide
CO_2	carbon dioxide
O_2	oxygen (gas)
O_3	ozone
N	nitrogen
NO_2	nitrogen dioxide
NO_x	oxides of nitrogen
P	phosphorus
Pb	lead
S	sulphur
SO_2	sulphur dioxide
SO_X	sulphur oxide

Units and Symbols

cm	centimetre
db	decibel
g	gram
Gj	gigajoule
h	hour
kg	kilogramme
kgoe	kilogramme oil equivalent
km	kilometre
kj	kilojoule

l	litre
lcd	litre consumption per day
m	metre
masl	metres above sea level
ml	millilitre
mld	million litres per day
m^3	cubic metres
mg	milligram
µg	microgram
pH	hydrogen-ion concentration
ppm	parts per million
PM-10	particulate matter ≤10 µm diameter
toe	tonnes of oil equivalent

Notes

Exchange rate

Values in Nepalese rupees have been converted to US$ at the exchange rates shown

Exchange (buying) rate for 1 US dollar (average for the year)

Year	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000
Nepali rupees (NRs)	27.4	29.1	42.7	42.6	49	49.1	50.5	56.3	56.8	67.6	68.2	70.5

Dates

Annual data for Nepal are sometimes collected according to the Gregorian calendar (January to December) but often according to the Nepali calendar (Bikram Sambat, which runs from approximately 15th April to 14 April the following year). In the latter case, year dates are given in the form 1978/79 and so on.

Table of Contents

Back Pocket

Transparent pullout sheet, outline map of Nepal with district names and boundaries, to use as an overlay with maps

Part I
Executive Summary

1.1 General Background of the Report

The National SoE Report of Nepal aims to provide guidelines for environmental action planning, policy setting, and resource allocation for the coming decades, based on sound analysis of the state of and trends in the nation's environment. This SoE report is prepared based on the UNEP format and is composed of four parts.

Part I is an executive summary of the status of the environment including environmental developments and key environmental issues.

Part II is an overall national overview of the major developments and trends of environmental resources.

Part III addresses five key priority issues in a 'Pressure-State-Impact-Response (P-S-I-R) Analytical Framework.'

Part IV is the conclusion, highlighting the key findings, emerging environmental issues, and major information gaps.

Annex 1 contains SoE Components; Annex 2, Participants at the In-country Training; Annex 3, List of Core Groups; Annex 4, List of Experts; Annex 5, List of Reviewers; Annex 6, Data Sources; Annex 7, List of Participants at the Consultative Meeting; Annex 8, District Codes; Annex 9, News clips.

The report is based on the best data available, but in many cases clear limitations and gaps were apparent. Data and information were derived from different sources, such as government annual reports, statistical reports, published papers, unpublished official records, and informal discussions with the experts/heads of various organisations/departments. Several meetings were also held with relevant government and other environmental experts to gather data on each of the specific issues.

1.2 Overview of Major Environmental Developments and Trends

Nepal has an area of 147,181 sq.km and an average north-south width of 193 km and east-west length of 850 km. It consists of three main physiographic regions, viz., Mountains, Hills, and Terai (plains). Of the country's total area, the mountain and hill regions together account for nearly 77% while the Terai region accounts for the remaining 23% of the area. But in terms of population, the Terai region had nearly 47% of the country's estimated total population of 22.37 million in 1999 and the Mountains and Hills the rest.

- The overview of the general environmental conditions of the country is given under two headings: environmental resources and social and economic driving forces. The country has diverse environmental resources: water, forests, land, climate and weather, and biodiversity. The country has enormous hydropower potential. Forests still occupy the largest proportion of the land area. The diverse climatic condition makes it possible to grow a wide variety of agricultural crops. With the diverse climatic conditions, together with the forests, the country is rich in biodiversity. Due to the lack of capital and human resources, commitment on the part of the government, and awareness among the general mass of the people, the country has not been able to utilise these vast resources to the extent desired. The resources are deteriorating instead. Landslides, soil erosion, deforestation, forest fires, and so on have caused the land to deteriorate, water sources to dwindle away, rivers to flood, biodiversity to deplete, and people to migrate into urban areas and elsewhere.
- Urban areas have developed haphazardly creating acute problems of solid waste, water pollution, air pollution, noise pollution, and others. The country has a broad-based population structure, indicating a high fertility rate. The gainful population is increasing, and is quite large compared to the availability of employment opportunities. Roads, the backbone of industrial

development and social, economic, political, and spatial integration, have not yet reached all 75 district headquarters and, therefore, most of the human settlements cannot be reached by road. The existing infrastructural facilities, including roads, electricity, health, schools, and water are inadequate, not only for the needs of the people but also in terms of use of existing resources.

1.3 Key National Environmental Issues

The key environmental issues of Nepal are related to forests, soil, solid waste, water, and air. These environmental resource bases are described in terms of a pressure-state-impact-response framework.

1.3.1 Forest depletion

The forests, a major resource base of Nepal, cover an area of 42,682 sq.km, 29% of the total land area, and shrub covers 15,601 sq.km or 10.6% of the total area. Forest depletion is one of the major environmental issues in the country. The forests have decreased in both area coverage and density over previous decades. Landslides, soil erosion, floods, encroachment of forests by cultivated land and people for settlement, among others, have been responsible for this.

- Out of the total land area in the country, the forest area, according to the Land Resources Mapping Project (LRMP) accounted for 38% in 1978/79; in 1994 the area had declined to 29%. The shrub area increased during the same period from 4.7 to 10.6%. This has been mainly due to uncontrolled cutting of trees for fuelwood and forest clearance for agricultural land.
- Between 1978/79 and 1994, the estimated rate of annual deforestation in the Hills was 2.3% compared to 1.3% in the Terai, while for the country as a whole it was 1.7%. During the same period, the annual decrease in forest and shrub together was 0.5%. In terms of area, the forests of the country decreased by 24%, while shrub area increased 126%.
- The agricultural area increased from 235,900 ha in 1980 to 2,968,000 ha in 1985 and then remained constant up to 1999. This increment was mainly due to the encroachment on forest areas. The forest was also encroached by development works and human settlements. In eastern Nepal, the forest area decreased as a result of construction of Bhutanese refugee camps in and around the forests.
- There has been a decrease in the growing stock rate of the trees. In 1985, the total growing stock was 522 million cubic metres of bark up to 10 cm top diameter, and this dwindled down to 387.5 million cubic metres in 1999. The growing stock for sal (*Shorea robusta*) in the Terai forests declined from 101 m^3/ha to 72 m^3/ha and for other hardwood forests the decline was from 76 m^3/ha to 58 m^3/ha.
- Fuelwood constitutes 78% of the total fuel consumption and its use is one of the main causes of forest depletion. This is basically due to the lack of alternative fuel to wood. As a result, distances from the villages to the forests have increased.
- The forest has also been under great pressure from the ever-increasing demand of the livestock population for grazing and fodder.
- Species of flora and fauna have also declined due to forest depletion. In 1996, 47 endemic plant species were found to be under immense threat. The country's threatened animal species, including mammals and birds, had shares of 3.8 and 2.3% respectively of the world's endangered species.
- Landslides, soil erosion, and floods have occurred as a result of the clearing of forests, particularly in the hills. While sedimentation has taken place in downstream areas, the occurrence of floods and landslides has also affected human life and property.
- Some government policies have appeared to contribute to forest depletion. For instance, the 'Private Forest Nationalisation Act 1957', which was implemented to consolidate the protection and management of the forests, rather led to degradation of the forests by providing people with uncontrolled access to forest areas. Similarly, the Land Tax Act 1977 encouraged people to cut trees standing around their farms, as the act defined land with forest as government land.

- Nepal has tried to mitigate forest depletion by passing legislation such as the Forest Protection Act (1967), National Parks and Wildlife Conservation Act (1973), National Forestry Plan (1976), Master Plan for the Forestry Sector (1989-2010), Nepal Environmental Policy and Action Plan (1993), Buffer Zone Regulation (1996), and Plant Protection Act (1997) and introduction of programmes like the community forestry programme. The government has adopted an appropriate technology for alternative energy to fuelwood. The Alternative Energy Promotion Centre (AEPC) has prepared a twenty-year master plan to provide alternative energy sources such as biogas, improved cooking stoves (ICS), and solar energy from photovoltaic systems.

1.3.2 Soil degradation

Nepal's mountains and hills are inherently vulnerable to landslides and soil erosion. The rapid growth of human and livestock population is putting severe pressure on Nepal's natural resources, especially soil.

- Deforestation, degradation of grasslands, encroachment of steep slopes, and intensive agriculture are leading to soil degradation. Unbalanced use of chemical fertilisers is also causing soil degradation through change in soil structure and acidification.
- Development works, particularly the construction of mountain roads without adequate conservation measures, have also contributed to landslides and soil erosion.
- Studies have shown that 60–80% of the total annual soil loss from cultivated terraces occurs during the pre-monsoon season.
- The declining soil fertility has resulted in stagnancy in the production of major food crops.
- The one-way flow of nutrients from forest to farmland has resulted in rapid depletion of nutrients in forest soils.
- The Ninth Plan (1997–2002) realised that the decline in crop production is mainly due to soil degradation.
- The policy responses of the government in terms of addressing the problem of soil degradation are the establishment of the Department of Soil Conservation and Watershed Management; formulation of the Soil and Watershed Conservation Act 1982 and its Regulations 1984; Forestry Master Plan; Community Forestry Programme; and Agricultural Perspective Plan.

1.3.3 Solid waste management

Solid waste management problems are caused by the introduction of plastic materials and changing consumption patterns, especially in urban areas, and these have resulted in an increase in the volume of solid waste.

- The urban population makes up about 15% of the country's total population. However, the rapid growth in urban population by over 5% per annum in Nepal has exerted tremendous pressure on the urban environment. One consequence of this is an increasing amount of garbage, which is often seen littering city streets or in dumps on the river banks and in other public places.
- Urbanisation in Nepal is characterised by haphazard and unplanned urban growth, inviting many environmental problems such as encroachment of public areas and river banks, air pollution, water pollution, and solid waste. Among these, solid waste seems to be the most visible problem.
- Households are the main sources of solid waste in Nepal. The per capita waste generation is estimated to be 0.48 kg per day. In 1999, about three million urban residents in Nepal's 58 municipalities generated a total of 426,486 tonnes of waste, to which the city of Kathmandu alone contributed 29%. Of the total waste generation in the country, solid waste made up about 83%, agricultural waste constituted 11%, and industrial waste accounted for 6%.
- The major types of hazardous waste generated in the country are medical waste, battery wastes, pesticides, and a few types of industrial waste. An estimated 500 tonnes of hazardous waste is

generated per year from hospitals and 235 tonnes from dry cell batteries including factory waste. Most of these wastes are either dumped with the rest of the garbage or burned in ordinary kilns. The total consumption of pesticides in the country is approximately 55 tonnes of active ingredients per year. BHC, aldrin, and endosulfan are commonly used pesticides. Most unused pesticides are thrown on to open dumps. Obsolete pesticides are classified as hazardous waste. Currently, about 67 tonnes of obsolete pesticides are stockpiled in unsafe conditions at various locations in the country.

- In 1980 solid waste management was introduced by establishing the Solid Waste Management and Resource Mobilisation Centre (SWMRMC) and a landfill site for solid waste in Kathmandu. Other policy responses include the Solid Waste Management National Policy (1996), Local Self-Governance Act (1999), and the involvement of the private sector in waste management in Kathmandu and Biratnagar.

1.3.4 Water quality

Rivers and groundwater are major sources of drinking water in Nepal. Over time, the country's requirements for water for drinking and personal hygiene, agriculture, religious activities, industrial production, and hydropower generation have increased.

- Major towns and cities in the Hills have acute problems of water availability. In the Kathmandu Valley, water supply meets only 79% of the total urban demand of 145 million litres/day during the rainy season. The carpet industries alone consume about 6.1 million litres of water per day and generate 5.5 million litres of waste water daily.
- In 1998, the total annual withdrawal of water for consumptive uses was 16.70 billion m^3/year, which accounted for 7.4% of the total capacity. In 1994, it was 5.8%. In other words, the annual per capita withdrawal of water was 760 m^3 in 1998, an increase from 650 m^3 in 1994.
- Nepal's rural settlements and the majority of urban areas do not have access to sewerage networks. The domestic waste water generated by these areas is discharged into local rivers without treatment.
- Forty per cent of Nepal's total industrial units (4,271) in 1992 were related to water pollution. In Kathmandu Valley, this accounted for 57% of total industrial units (2,174). All industrial wastes in most cases are directly discharged into local water bodies without treatment.
- The use of chemical fertilisers (NPK) per hectare increased tremendously from 7.6 kg in 1975 to 26.6 kg in 1998.
- The decline in forest area reduced the water recharge capacity of groundwater sources.
- The water quality of rivers and lakes flowing through the large urban areas is deteriorating. The water quality of rivers flowing in remote areas is still acceptable.
- The quantity of water for household uses is severely limited and the quality of drinking water is poor in most cases, mainly due to the lack of treatment plants.
- The rivers are also major places for disposal of urban solid waste and industrial effluents.
- Patient visits to hospitals because of diarrhoeal problems have increased tremendously. A report obtained from a local hospital in Kathmandu showed that 16.5% of all deaths were due to water-borne diseases.
- Rivers, ponds, and lakes, particularly in the major urban areas, have been greatly affected by dumping and discharging of household waste, sewerage, and industrial affluents into them. The aesthetic value and biodiversity of water bodies have also been affected.
- The policy measures for water resource conservation include the Water Aquatic Animals Protection Act (1965), Solid Waste Act (1987), Solid Waste Regulations (1989), Water Resources Act (1992), and Resources Regulations (1993).

1.3.5 Air pollution

Air quality, particularly in the large urban areas of Nepal, has deteriorated. Several factors are responsible for this.

- The energy supply in Nepal comes largely from traditional sources such as fuelwood, agricultural residues, and animal waste. These sources make up nearly 90% of the total energy consumption. Other sources like petroleum fuel, coal, and electricity share the remaining 10%.
- The number of vehicles is rising rapidly, particularly in the major urban areas. The total number of vehicles in the country increased from 75,159 in 1990 to 220,000 in 1998. The two-wheeler was the largest, accounting for nearly 51% of the total vehicles. As a consequence, the consumption of petrol and diesel increased from 31,056,000 litres and 195,689,000 litres in 1993 to 49,994,000 litres and 315,780,000 litres in 1998. All the vehicles (four wheels and two wheels) are responsible for emitting pollutants such as carbon monoxide, hydrocarbons, nitrogen dioxide, sulphur dioxide, suspended particulate matter, smoke, and soot.
- In 1994, Nepal's total industries numbered 4,487, of which 74% were classified as air polluting industries. Of the total air polluting industries, Kathmandu alone had 33%.
- Emission of carbon dioxide was estimated to be 15.45 x 10^7 tonnes in 1999. Annual emission of greenhouse gases (GHGs) from petroleum products was estimated at 72,000 tonnes of carbon and 1790 tonnes of nitrogen from 1970-1990. Methane production was 1.2 million tonnes in 1997. Due to deforestation and burning of fuelwood, the concentration of carbon dioxide (CO_2) in the atmosphere has increased. It is estimated that the annual deforestation of 26,602 hectares of land has emitted 7.77 million tonnes of CO_2 into the atmosphere.
- The 1996 survey identified CFC-12 and HCFC-22 as the only ODS consumed in Nepal, about 29.058 tonnes and 23.04 tonnes per annum respectively. There is no production of ODS substances in Nepal.
- The impacts of air pollution in Nepal are as follow.
  - Air pollution has had a direct impact on human health. Respiratory diseases increased from 10.9% of the total outpatient visits (5,167,378) in 1996 to 11.6% of the total outpatient visits (7,115,981) in 1998.
  - The inhabitants of Nepal's mountain region are much more vulnerable to respiratory diseases because of the burning of fuelwood in poorly ventilated houses. Hospital records show that a greater number of respiratory diseases occurred in the urban population than in the rural population; and this may be due to the smoke and dust emitted from vehicles and industries. Acute Respiratory Infection (ARI) accounted for more than 30% of total deaths in children under five years of age. A significant proportion of the population, in both rural and urban areas, is affected by bronchitis caused by domestic smoke.
  - The air quality in Nepal's major urban areas has deteriorated because of the emission of smoke from vehicular traffic. Dust particles emitted by cement factories have caused an adverse impact on vegetation growth, as well as low visibility and low degree of incoming sunlight.
- The measures undertaken by His Majesty's Government of Nepal to mitigate air pollution are the Industrial Enterprises Act (1992), Vehicles and Transport Management Act (1993), Nepal Petroleum Products Act (1993), Nepal Mines Act (1996), Environmental Protection Act (1996), and Nepal Vehicle Mass Emission Standard (2000). Restriction of the registration of two-stroke engine vehicles in important tourist towns is an important measure for mitigating air pollution in Nepal. Nepal had ratified the Montreal Protocol in 1996 and, accordingly, the Ministry of Industry has introduced activities to phase out ODS by 2010.

1.4 Conclusion

The discussion of the five key environmental issues, viz., forests, soil, solid waste, water, and air, indicates that environmental conditions are deteriorating, despite several policy measures undertaken by the Government of Nepal. The rapid and uncontrolled growth of population and poor management and use of the available resources are the major reasons for the deterioration. The reason for these is the inadequacy of capital and human resources and lack of public awareness. For sustainable development of the environment, strong commitment on the part of the government to implement programmes that are appropriate and encourage already existing programmes is required.

Part II
Overview of Major Environmental Developments and Trends

2.1 Background

2.1.1 Nepal

With an area of 147,181 sq.km, Nepal is a preponderantly mountainous country. Sandwiched between India on three sides - east, west, and south – and China to the north, Nepal has an average north-south width of 193 km and east-west length of 885 km. The altitude varies from 90 metres above sea level (masl) in the south to 8,848m in the north. There are three ecological regions: the Mountains, the Hills, and the Terai (plains). The administration in Nepal is carried out through 75 districts, 58 municipalities, and 3,912 Village Development Committees (Map 2.1). In 1999, Nepal had an estimated population of 22.4 million, of which about 3.3 million or 14.5% lived in urban areas. The kingdom has a large number of diverse ethnic groups, distributed throughout the country.

2.1.2 The State of the Environment Report

In November 1998, the Norwegian Agency for Development Cooperation (NORAD) and the United Nations Environment Programme/Environment Assessment Programme for Asia and the Pacific (UNEP/EAP.AP) together established a project aimed at 'Strengthening the Environmental Assessment and Monitoring Capabilities in South Asia and the Greater Mekong Sub-Region' – SEAMCAP. The project is active in nine countries, of which Nepal is one.

The project's main goal at national level is to assist in strengthening the capacity of the national governments to establish a strong information technology base for data processing, modelling, and analysis. In each country there are two components: first, to produce a data set on different environmental components; and second, to prepare a State of the Environment (SoE) report using the data set. The country SoE reports will be used in the preparation of UNEP's Decadal 2002 Global SoE Report. The way in which the project was developed in Nepal is described below.

A participatory approach was adopted for the collection of the data sets related to different environmental components.

- In June 1999, a five-day 'training course for trainers' was held by the international team for the national experts involved in the project on different aspects of the database design and the preparation of the country SoE report. Immediately afterwards, an in-country training course was held for officials representing different government and non-government agencies on data collection and processing according to the UNEP database format (Annex 2). The trainees from these two courses were considered to be the 'core group' (Annex 3).
- Core group members discussed the progress and verification of the collected data sets during regular meetings.
- The collected data were assembled, processed, and entered according to the database format given for the SoE.

The five key issues were identified using a composite index method (SEAMCAP 2000). Fifty-six environment experts were each asked to select the five most important issues from a total of 18 they had proposed. The index value for an issue was calculated from the percentage of experts selecting that issue. The issues are presented in the SoE in the order of importance indicated by the index (forest depletion was selected by 85% of the experts, air pollution by 60%).

The first draft of the report was discussed at a consultation meeting involving experts from various government and non-government organisations (Annex 6). The comments made were incorporated in the final report.

Considerable problems were encountered in processing the data in a consistent and comparable way. The main difficulty was that most data had been collected for project or department specific purposes, and therefore did not match in terms of year collected, type of calendar year used (Roman or Nepali), geographical area, definitions and classifications used, and/or other attributes. Equally, there was considerably more data available for the Kathmandu Valley than for other parts of the country – or the country as a whole. Even those data sets available at national level tended to be scattered and incomplete. Much effort was needed during the data processing phase to tabulate the data in a comparable form. Even after this, there were clearly many limitations remaining in the data set. The methods used to estimate and extrapolate data are described in the report on the SoE data set (SEAMCAP 2000).

The definitions of parameters were essentially derived from the Global Environmental Outlook-2 (GEO-2). However, some definitions that did not match or were not available in GEO-2 were defined in the Nepalese context with the help of the experts concerned.

To summarise, the information given in this report is based on the best data available, processed in a consistent and compatible manner. But there were clearly many limitations and gaps. Preparation of this report has helped to highlight the need for more and more consistent collection of data in Nepal, and to identify the major areas of need for data collection.

2.2 Environmental Conditions

Nepal's major environmental resources are land, water, forest, and faunal and floral bio-diversity. The major developments and trends in terms of environmental resources and associated socioeconomic driving forces are described below. Pertinent significant environmental issues (SEI) are described below. They are assigned to three categories in terms of level of urgent need: high, medium, and low.

2.2.1 Land

Land is a principal resource of Nepal and constitutes about 97% of its total area. But the country's topography is rugged with over three-quarters of the total area made up of mountains and hills (Himalayas, Mahabharat, and Churia) and intermontane valleys (Map 2.2). The southern narrow plains strip is known as the Terai; it makes up less than one-third of the total area but it has the largest proportion of the population (Table 2.1). The hills in the country's middle belt are geologically fragile but are favourable for human habitation. The hills constitute the largest area but have a slightly lower population than the Terai which is spread widely over the entire area.

Table 2.1: Area, population and number of districts by geographic region

Physiographic region	Area		Number of districts	Estimated population in 1999 (million)	
	km²	%		Size	%
Mountains	51,817	35.2	16	1.7	7.8
Hills	61,345	41.7	39	10.2	45.5
Terai	34,019	23.1	20	10.5	46.7
Total	**147,181**	**100**	**75**	**22.4**	**100**

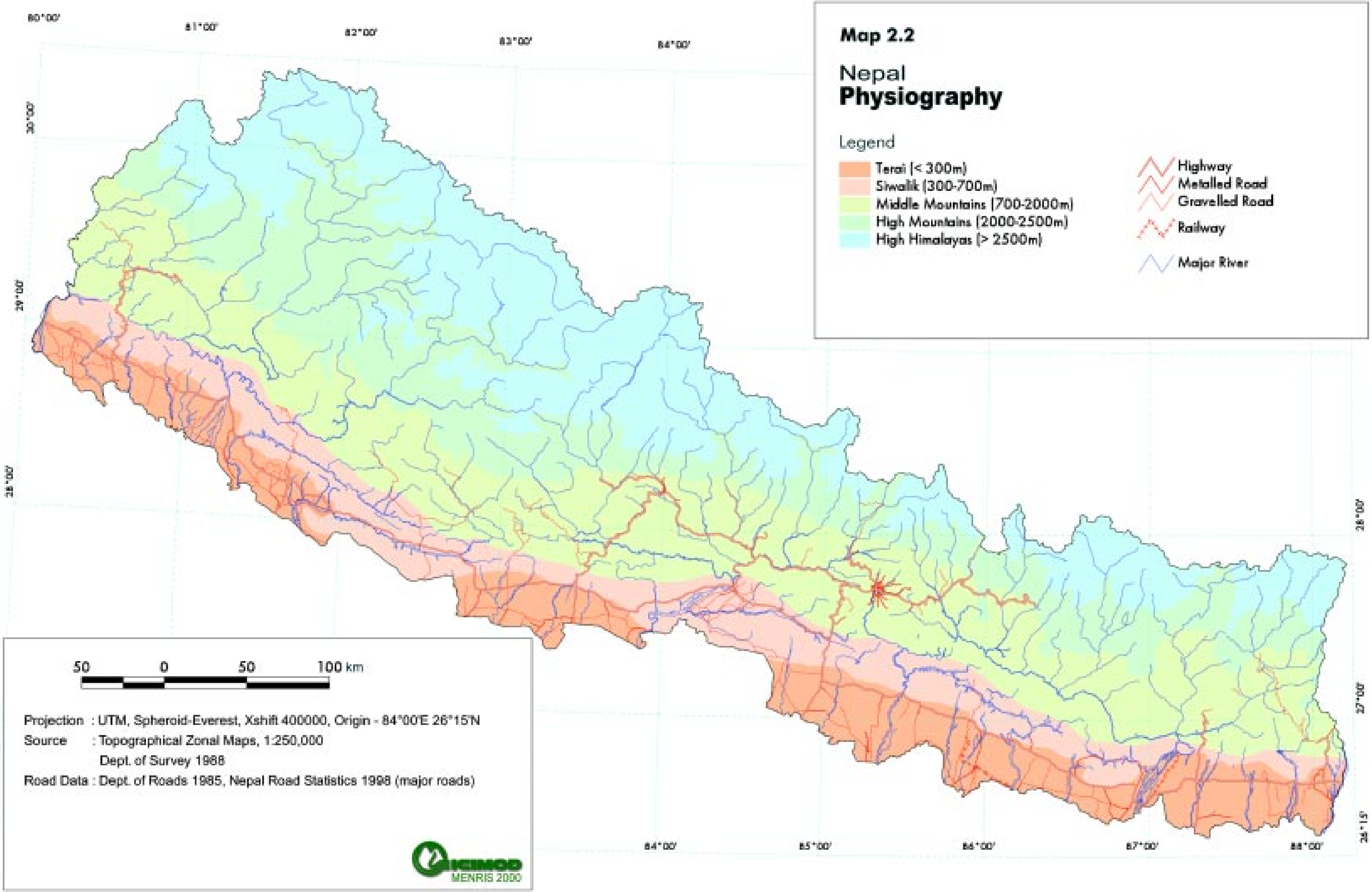
Source: CBS (1999); CBS (2000)

The distribution of land according to land-use type is shown in Table 2.2.

- Agricultural land is the second largest category in terms of land-use with 20% (Table 2.2) after forest land which occupies 29% of the country's land-use types. However, it has been subject to immense pressure. Expansion of agricultural land is a major problem, and still continues in the attempt to meet the growing demands of the population. The growth in population is over two per cent per annum. Each year, the increasing population has no other way but to count on agriculture and its related activities due to very limited opportunities in terms of non-farm activities. The agricultural land area has increased from 2,376 thousand hectares in 1980 to 2,968 thousand hectares in 1985. Somewhat

Map 2.1

Nepal
Administrative Boundaries


Map 2.2
Nepal
Physiography
Legend
Terai (< 300m)
Siwalik (300-700m)
Middle Mountains (700-2000m)
High Mountains (2000-2500m)
High Himalayas (> 2500m)
Highway
Metalled Road
Gravelled Road
Railway
Major River
80°00'
81°00'
82°00'
83°00'
84°00'
85°00'
86°00'
87°00'
88°00'
30°00'
29°00'
28°00'
27°00'
26°15'
50 0 50 100 km
Projection : UTM, Spheroid-Everest, Xshift 400000, Origin - 84°00'E 26°15'N
Source : Topographical Zonal Maps, 1:250,000
Dept. of Survey 1988
Road Data : Dept. of Roads 1985, Nepal Road Statistics 1998 (major roads)
ICIMOD
MENRIS 2000

surprisingly the agricultural area has been recorded as constant from 1985 to 1999 (DoA 1999). This might be explained in part by the concomitant loss of agricultural land to housing roads, and other construction works, or there may be a data collection or definition problem. The per capita agricultural land has declined from 0.16 ha in 1980 to 0.13 ha in 1999 (CBS 1999). In other words, the person-land ratio (cultivated land) increased considerably from 4.7 in 1971 to 7.5 persons/ha in 1999 (CBS 1999). In the Terai, the person-land ratio has increased from 3.1 in 1971 to 8 persons/ha in 1999, while during the same years there were 6.5 and 11 persons/ha in the hills, respectively (CBS 1999).

Table 2.2: Land-use pattern (1999)

Land-use type	Area ('000 ha)	%
Cultivated land	2,968	20
Non-cultivated land	998	7
Grass land	1,745	12
Forest land	4,269	29
Shrub land/degraded forest	1,559	11
Other land uses	3,179	22
Total	**14,718**	**100**

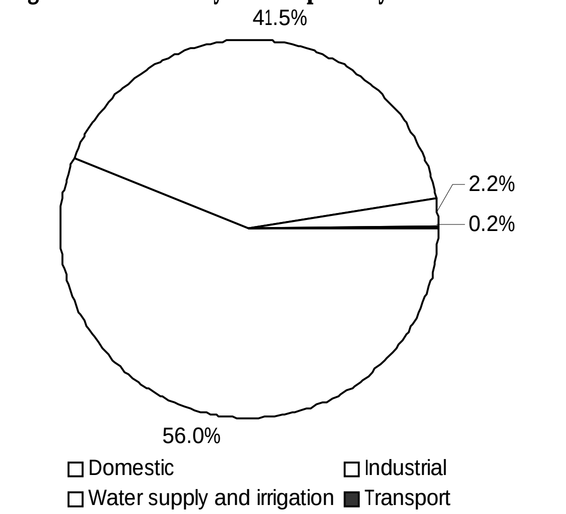
Source: DOA (1999); FSD (1999); ICIMOD (2000)

2.2.2 Water

Water is the largest natural resource of Nepal. The country's water requirements are for drinking and personal hygiene, religious activities, agriculture, industrial production, hydropower generation, and recreational activities such as swimming and fishing. There is a growing pressure on water resources due to the growth of population, expansion of irrigation systems for increasing agricultural production, urbanisation, and industrial expansion. The following are the features of the water resources.

- Nepal has over 6,000 rivers and streams. The annual mean flow for the snow-fed major rivers is estimated to be 4,930 m^3/sec. This amounts to 70% of the total annual surface runoff. About 60 to 85% of the annual surface runoff occurs during the monsoon period (June-September).
- The total available surface water potential (annual run-off) in the country is estimated to be 224 billion m^3. The estimated ground water potential in the Terai is 12 billion m^3 of which 5.8 to 9.6 billion m^3 could be extracted annually (estimated recharge) (MOWR 1999). The ground water potential for the country is unclear but probably not much larger, the same figure of 12 million m^3 is quoted as referring to the country as a whole in WECS (1999). Current groundwater withdrawal is about 0.52 billion m^3 per year (WECS 1999).
- Per capita internal renewable water resources declined from 13,800 m^3/year in 1984 to 10,300 m^3/year in 1998.
- The surface water and groundwater sources have deteriorated, especially in urban areas. Extraction of groundwater is rising to meet the growing demands of the population for domestic, industrial, and agricultural purposes. It is overexploited beyond its capacity in the Kathmandu Valley (Metcalf 2000). The water table in the Kathmandu Valley has lowered substantially due to low recharge, which is a result of decreasing forest coverage, increasing urban build-up, and other non-agricultural development activities.
- The demand for water for irrigation for agriculture has increased tremendously. The irrigated area expanded from 0.439 million ha in 1984 to about 0.88 million ha in 1998 (MoA 1999). About 90% of the total water consumed is used for irrigation.
- Despite having 83,000 megawatts capacity for hydropower generation, only 252 megawatts have been generated, i.e., 0.3% of

Figure 2.1: Electricity consumption by sector



Source: NEA (1999)

the total potential (NEA 1999). Electricity consumption has increased enormously over the past 15 years, although the per capita consumption is still only 50 kWh per annum. The domestic sector is the major user (Figure 2.1).

2.2.3 Forest

Forests are the largest natural resource in terms of area coverage. A majority of the Nepalese people use the products of forests for firewood, fodder, timber, and medicines. As a result, the forest has dwindled in both area and quality due to the constantly increasing demands of the people for forest products (Table 2.3).

Table 2.3: Change in forest and shrub cover (1978-1994)

Type	1978-79	1985-86	1994
Forest	38.0	37.4	29.0
Shrub	4.7	4.8	10.6
Total	**42.7**	**42.2**	**39.6**

Source: DFRS (1999)

About 29% of the area of Nepal is under forest coverage and 10.6% is under shrubs or so-called degraded forest coverage. The forest area, which was 45% in 1966 and 37% in 1986, has declined considerably. Conversely, the shrub land area doubled from 5% in early 1980 to 10.6% in mid-1990. The annual deforestation rate is estimated to be 1.7% (DFRS 1999).

The following are the major characteristic features of forest resources.

- About 80% of the total population depend on forests for fuelwood (WECS 1997). The fuel consumption for household and industrial biomass is estimated to be 15.4 million tonnes per year for 2000 compared to 11.3 million tonnes per year in 1985. Per capita fuelwood consumption in the Hills is estimated to be 640 kg, while it is 479 kg/person/yr for the Terai. The per capita timber consumption per annum was estimated at 0.07 m^3/yr in 1985 and will increase to 0.11 m^3/year by the year 2000. The timber demand at national level was projected to be about 2.5 million m^3 by the year 2000.
- Forest products contribute about 42% of the total digestible nutrients (TDN) of cattle. If the present conditions continue, the fodder supply for the TDN requirement will be in deficit by about 0.2 million tonnes by the year 2010 for the country as a whole (HMG/ADB/FINNIDA 1988).
- Between 1986 and 1999 about 0.155 million hectares of forest area were consumed by such uses as settlement, agriculture, institutional buildings, and roads (DFRD 1999). Thus, the per capita forest declined from 0.630 in 1964 to 0.442 in 1979 and further to 0.198 hectares in 1998.
- The forest area in the Terai region declined by 0.1 million hectares between the late 1950s and 1985 due to the planned resettlement programmes undertaken in the forest area. About an equal area of the forest was occupied illegally by migrants for settlement during the same period.
- The forest area has also declined due to continued extraction of non-timber forest products (NTFPs). Revenue through trade in NTFPs doubled from a current price of US$ 0.4 million in 1985 to US$ 0.8 million in 1997 (MoF 1999). Five out of over 100 plant species used in the trade include bojho (*Acorus calamus*), kutki (*Picrorhiza kurroa*), padamchal (*Rheum emodi*), chiraito (*Swertia chirayita*) and sugandawal (*Valeriana wallichii*).
- One striking feature of forest resource development undertaken recently is leasehold forest managed through users' groups. In 1993, a total of 270 hectares of state-managed forest was handed over to user groups for leasehold forest and it was increased to over 1,100 hectares in 1996.
- Sustainable management and development of forests through involving communities as forest user groups is very important with regard to forest development in the country. In 1999, the government handed over a total of about 0.606 million hectares of state-owned forest to over 8,300 community forestry user groups for development, conservation, management, and

sustainable use of the forests. A total of 0.929 million people is directly benefited by being members of user groups.

- Another feature of forest conservation is to manage the forest area in protected areas such as national parks, wildlife reserves, and conservation areas. Such protected areas have increased from 0.976 million hectares in 1984 to 2.476 million hectares in 1998.

2.2.4 Forest fire

Every year forest fires occur in many places, events that cause heavy loss of property as well as loss of many species of wildlife. Though the records of forest fires are limited, those recently recorded by the Department of Forests are shown in Table 2.4. Forest fires are mainly caused by the ignorance and illiteracy of local people and the personal interests of illegal woodcutters, poachers, encroachers, charcoal traders, and so on. It is noted that about 45% of forest fires with known causes are due to burning areas to make way for new grass to graze cattle and the ignorance of cigarette smokers. About 64% of forest fires are set off intentionally by local people, only 32% are accidental (Sharma 1996). Fire line management is one of the most important remedies for minimising the impact of forest fires (Table 2.5).

Table 2.4: Forest fire and financial loss (1998)

Number of occurrences	**20**
Area of forest fire ('000 ha)	15.14
Financial loss estimated ('000 US $)	127.5

Source: DOF (1999)

Table 2.5: Fire line management

Fiscal year	Length (km)
1992	21
1993	54.6
1994	27.93

Source: CBS (1998)

2.2.5 Biodiversity

Nepal has a wide variety of plants and animals as a result of its large topographical and climatic variations. With this variety of biodiversity, people have established different levels of relationships with their surroundings for use, misuse, or development. The different biological species play a role not only in establishing symbiotic relationships among themselves in protecting natural resources but also have great economic value. These aspects are yet to be ascertained in detail. However, plants and animals in Nepal are under great pressure as they are considered common property.

- Nepal has identified 17 protected areas wherein the protection of species is ensured (Table 2.6). These protected areas (national parks, conservation areas,

Table 2.6: Protected areas established 1973-1998

Protected area	Year established	Area '000 ha
Conservation area		
Annapurna Conservation Area	1986	762.9
Makalu Barun Conservation Area	1991	83.0
Kanchenjunga Conservation Area	1998	205.0
Manaslu Conservation Area	1998	166.3
Wildlife and hunting reserve		
Dhorpatan Hunting Reserve	1987	132.5
Parsa Wildlife Reserve	1984	49.9
Royal Sukla Phanta Wildlife Reserve	1976	30.5
Shivapuri Watershed and Wildlife Reserve*	1976	9.7
Koshi Tappu Wildlife Reserve	1976	17.5
National park		
Makalu Barun National Park	1992	150.0
Khaptad National Park	1984	22.5
Langtang National Park	1976	171.0
Rara National Park	1976	10.6
Royal Bardia National Park	1976	96.8
Royal Chitwan National Park	1973	93.2
Shey Phoksundo National Park	1984	355.5
Sagarmatha National Park	1976	114.8

* Previously, Shivapuri Watershed and Wildlife Reserve (1984) had an area of 144 km^2 which included large settlements that are now no longer in the reserve.

wildlife reserves, and hunting areas), present excellent examples of diverse species of plants and animals ranging from sub-tropical to cold desert climatic types.

- In unprotected public areas, habitats have suffered great threat as a result of loss or alteration, over-extraction, illegal collection of species, poaching or hunting of wild animals, over-grazing, fire, and commercial trade. The economic value of endangered or rare species on the world market is very high which encourages poaching. Nepal, during the last two decades, lost 63 rhinos due to poaching (MFSC 1997).
- Nepal has a very wide variety of plant species in relation to its area coverage, which constitutes only about 0.03 % of the world's total landmass. Table 2.7 illustrates the species' types and Nepal's share in the world.
- Overall, Nepal's non-flowering species share is slightly below three per cent of the world's total and that for flowering plant species (angiosperms and gymnosperms) over two per cent. Endemic species of plants discovered in Nepal are confined primarily to its Himalayan region. Shrestha and Joshi (1996) have documented 60 non-endemic and 47 endemic plant species as threatened. Of the 60 non-endemic plant species, 22 are rare, 12 are endangered, and 11 are vulnerable. Of the endemic plants, 8 are extinct, 1 is endangered, 7 are vulnerable, and the remaining 31 fall into the International Union for the Conservaton of Nature's (IUCN) rare species' category. Shrestha and Joshi identified over 1,000 species of angiosperms in Nepal, of which 93 have the *nepalensis* epithet. Of the 93 *nepalensis* plant species, 32 are endemic.

Table 2.7: Nepal's share in global plant species

Groups	Nepal		World species	Nepal's share (%)
	Species	Endemic spp		
Non-flowering plants				
Algae	687	13	40,000	1.72
Fungi	1,822	150	70,000	2.38
Lichen	471	48	17,000	2.77
Bryophytes	853	37	14,000	6.09
Pteridophytes	383	NK	12,000	3.19
Non-flowering total	4,216	248	153,000	2.76
Flowering plants	5,833	246	250,000	2.33

Source: DPR (1996)
NK – not known

- Nepal is equally rich in animal diversity. The country has over 4.3 and 8.5% of the world's total of mammals and birds, respectively (Table 2.8). Of 656 butterfly species, 29 are endemic, 142 are threatened, and 12 are endangered (BPP 1995). Out of 185 fish species, 8 are endemic, 9 are vulnerable, and 24 are rare (Shrestha 1995). The spider species recorded in Nepal are found at altitudes ranging from 1,000 to 6,500m (Thapa 1995). A total of 847 bird species is found in Nepal: 11 extinct, 2 endemic, 22 IUCN threatened, and 40 cited in the Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES) appendices. Of the 185 mammal species, three are considered extinct (Uprety 1998).

Table 2.8: Nepal's share in global animal diversity

Groups	Nepal		World species	Nepal's share (%)
	Species	Endemic spp		
Arthropods				
Insects	5,052	4	1,000,000	0.44
Butterflies	656	29	NK	NK
Moths	789	NK	NK	NK
Spiders	144	108	NK	NK
Freshwater fishes	185	8	85,000	0.21
Herpetofauna				
Amphibians	43	9	4,000	1.07
Reptiles	100	2	6,500	1.53
Birds	847	2	9,881	8.57
Mammals	185	1	4,327	4.27

Source: MOPE (2000); Thapa (1997)
NK = Not known

- Nepal has a wide variety of domesticated plants and animals. Over 400 species of agro-horticultural crops and about 200 species of vegetables have been reported (NAA 1995), of which around 50 species have been domesticated for commercial and household consumption. Fifteen fruits with more than 100 varieties, 50 vegetables with 200 varieties, and 10 varieties of potatoes are cultivated commercially. Some wild genotypes have also been identified and domesticated by local people because of their economic value. The Nepal Agricultural Research Council (NARC) has stored the germplasm of various crops - cereals, grain, legumes, oilseeds, vegetables, and spice species – a total of about 8,400 accessions. There are about 680 accessions for rice and 713 for finger millet.
- In Nepal, biodiversity has been managed by conserving forest resources in eight national parks, three wildlife reserves, four conservation areas, one wildlife reserve/watershed conservation area, and one hunting reserve (in 1998). The Langtang National Park, the Royal Bardiya National Park and the Royal Chitwan National Park also have buffer zones of 420 km^2 , 327 km^2 , and 750 km^2 respectively in addition to the protected area (Table 2.6). The protected areas account for about 17% of the total area of the country. Of these, two, the Sagarmatha National Park and the Royal Chitwan National Park, have been included on the World Natural Heritage List and the Koshi Tappu Wildlife Reserve has been designated as a Ramsar Site. The population of endangered species, viz., the rhino, has increased from 80 in the late 1960s to over 450 in 1994. Its number is estimated to have reached about 600 in the late 1990s.
- To ensure conservation of biodiversity, the government has given legal protection status to 13 plant, 26 mammal, 9 bird, and 3 reptile species. Almost all these faunal species and about 20 plant species are included in the CITES appendices.

2.2.6 Atmosphere and climate

Nepal has a wide variety of climates from subtropical in the south, warm and cool in the hills, to cold in the mountains, which determine overall biodiversity and development activities. Throughout the year there are three broad but distinct seasons. The first is the hot and rainy monsoon, prevailing from June through September, during which four-fifths of the total annual precipitation of 1,530 mm occurs. The second is the post-monsoon season lasting roughly from October through January. In the beginning, the weather is characterised by warm and moist, followed by cool and cold, weather. This is also the harvesting season for agricultural crops. The third type is the pre-monsoon season, extending roughly from February to May, when it is dry and hot. Thus, the latter two seasons are almost dry but with showers of rain caused by cyclonic winds which originate from over the Mediterranean during the winter months (December-February). Geographically, this rain affects the western part of the country more.

- Because of variation in altitude, temperature in Nepal generally decreases from the south to the north with some exceptions in the valleys and tars (upland plains) of the Hills (Maps 2.3 and 2.4). Table 2.9 describes the average

Table 2.9: Average precipitation and temperature conditions (1988-1998)

Meteorological stations*	Meteorological parameters		
	Precipitation (mm)	Temperature (°C)	
		Max.	Min.
East			
Biratnagar	1943	19	30
Dhankuta	904	15	24
Bhojpur	1041	13	21
Centre			
Janakpur	1361	20	31
Kathmandu	1688	12	26
Jiri	2235	8	21
West			
Bhairahawa	1979	19	31
Tansen	1634	16	25
Pokhara	3957	16	27
Far West			
Nepalganj	1480	19	31
Surkhet	1431	16	28
Dailekh	3098	11	26

Source: CBS (1998); DHM (1998)

precipitation and average maximum and minimum temperature values for the years 1988 to 1998 at selected stations.

- The distribution of rainfall over the country is spatially varied and generally decreases from east to west with a few exceptional cases in the west (Map 2.5). As the Himalayas act as a barrier against the direction of the monsoon wind flow, the southern slope gets most of the rain from this wind, while the northern part of the Himalayan range on the leeward side is a rainshadow region with little or no rain (Map 2.6). The monsoon influence remains longer in the east than in the west as it travels from east to west and retreats from west to east. However, the highest mean annual rainfall of 5,202 mm was recorded at Lumle in central Nepal on the southern side of the Annapurna Himalayan range, whereas the lowest, 174 mm, was observed at Mustang on the other side of the same range (CBS 1994). All the areas lying beyond the Himalayas, particularly in the west, are dry areas (Maps 2.7 and 2.8). In some desertification has taken place partly due to an excessive number of livestock relative to the availability of scanty vegetation.
- One of the causes of climatic change is the greenhouse effect. Fossil fuel combustion, deforestation, and land use change are major causes of the increase in the gases of carbon dioxide (CO_2), methane (CH_4), sulphur oxides (SO_x) and nitrous oxides (NO_x), causing a rise in temperature. The estimated volume of CO_2 caused by deforestation and land use change was 3.96×10^6 tonnes in 1960. It increased to 15.45×10^7 tonnes in 1999 (SEAMCAP 2000). Between 1970-1991 the estimated annual emission of greenhouse gases through petroleum exhaust was 72,000 tonnes of carbon (C) and 1,790 tonnes of nitrogen (N) (Devkota 1992). Boden et al. (1995) have estimated an emission of 354,000 tonnes of CO_2 through combustion of fossil fuels between 1950 and 1992.
- Major urban areas have experienced a rise in temperature over the last few years. The average temperatures in some urban areas are still rising.

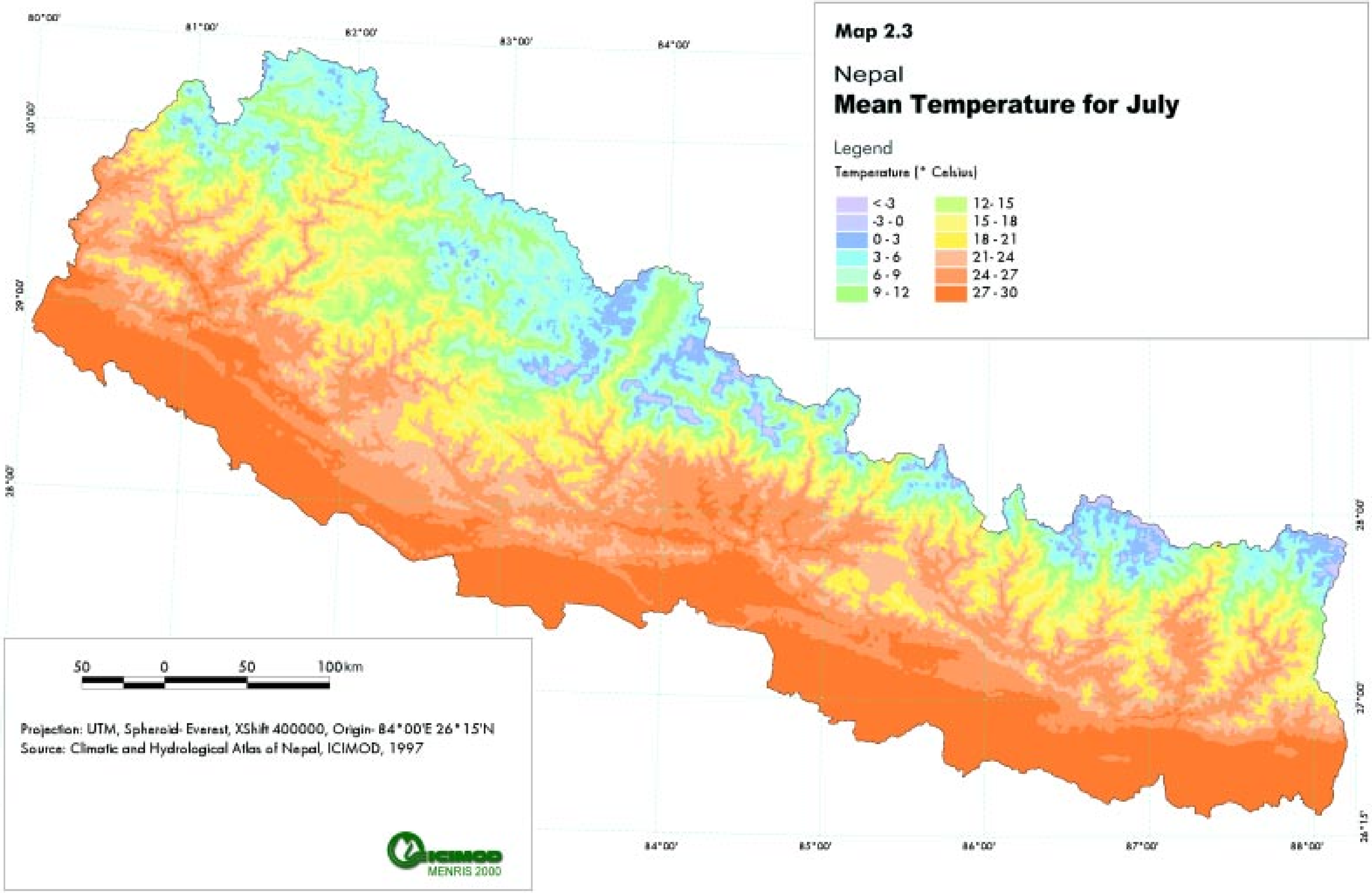
2.2.7 Solid waste

Domestic and industrial solid wastes are increasing along with the increasing population and industrial and commercial activities. Sample estimates in the Kathmandu Valley indicate the waste generation rate to be in a range of 0.25 to 0.45 kg/person/day. Nearly three-quarters of the total waste generated in different cities in Nepal is organic or biodegradable, indicating a low amount of waste requiring safe disposal. However, in Hetauda and Birgunj, it has been estimated that only 50% of the total waste generated is biodegradable (MoPE 2000).

Although waste generation is a common phenomenon, its safe disposal has become a major problem in urban and industrial areas. It has been so because of the lack of sanitary landfill sites. In Nepal, there is only one sanitary landfill site, at Gokarna – a few km north-east of Kathmandu proper within the Kathmandu Valley. This landfill site is used to dispose of the waste generated in the valley. In spite of this facility, domestic waste is also disposed of on river banks in the valley. In other areas, domestic and industrial wastes are disposed of on the river banks or in public places, thereby increasing pollution loads and health hazards.

2.2.8 Transboundary movement of wastes

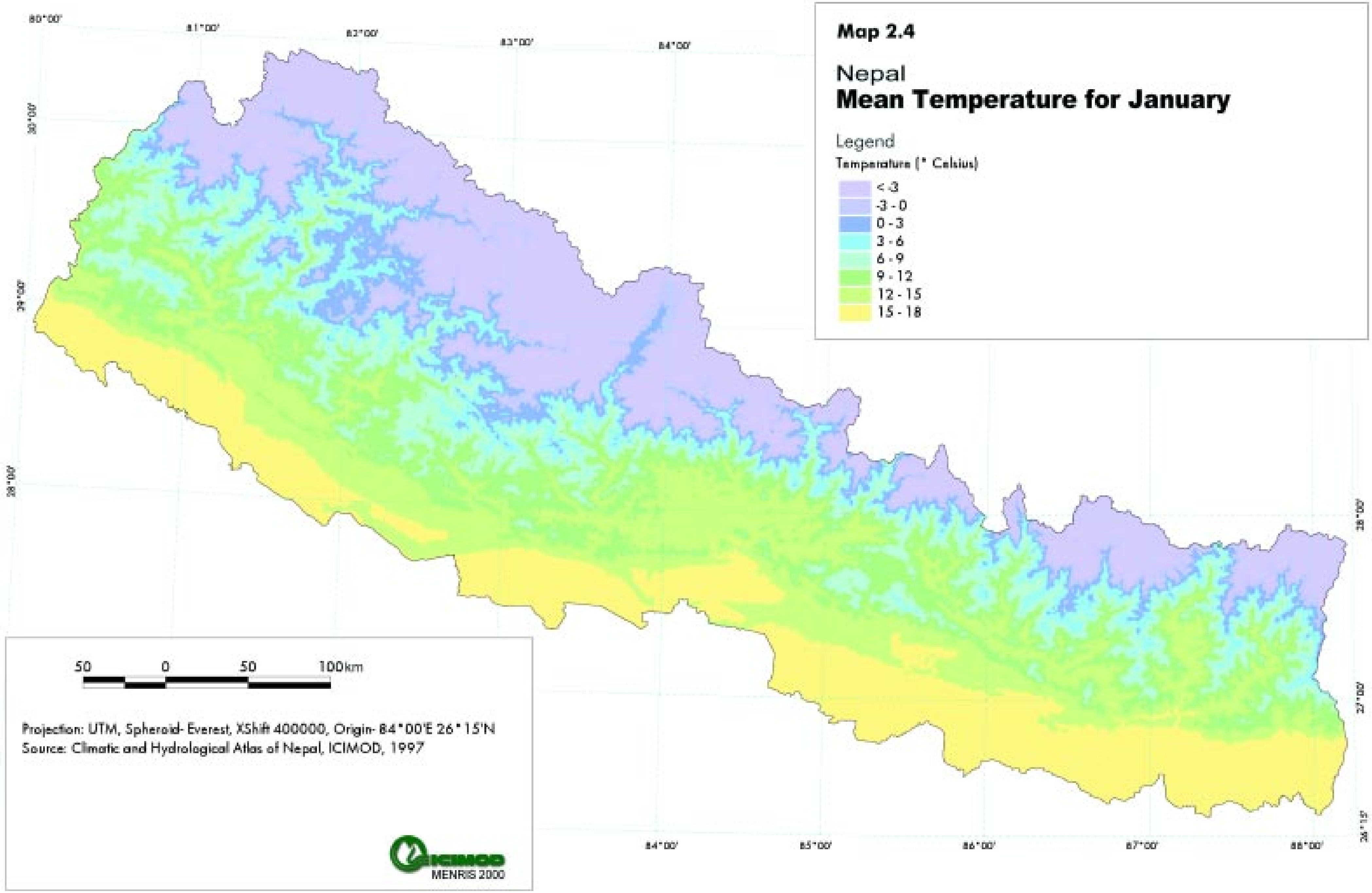
Although waste generation, accumulation, and disposal problems are common phenomena in Nepal's urban and industrial areas, there is an increasing trend to import or export non-biodegradable wastes such as scrap, plastic, glass, and so on. Transboundary movement of such waste has not yet been considered a major issue; however, it will likely encourage industries that use scrap as raw material. Hence, this issue demands close attention to comply with international, legally binding instruments as Nepal is a Party to the Basel Convention which facilitates regulation of transboundary movements of hazardous wastes.

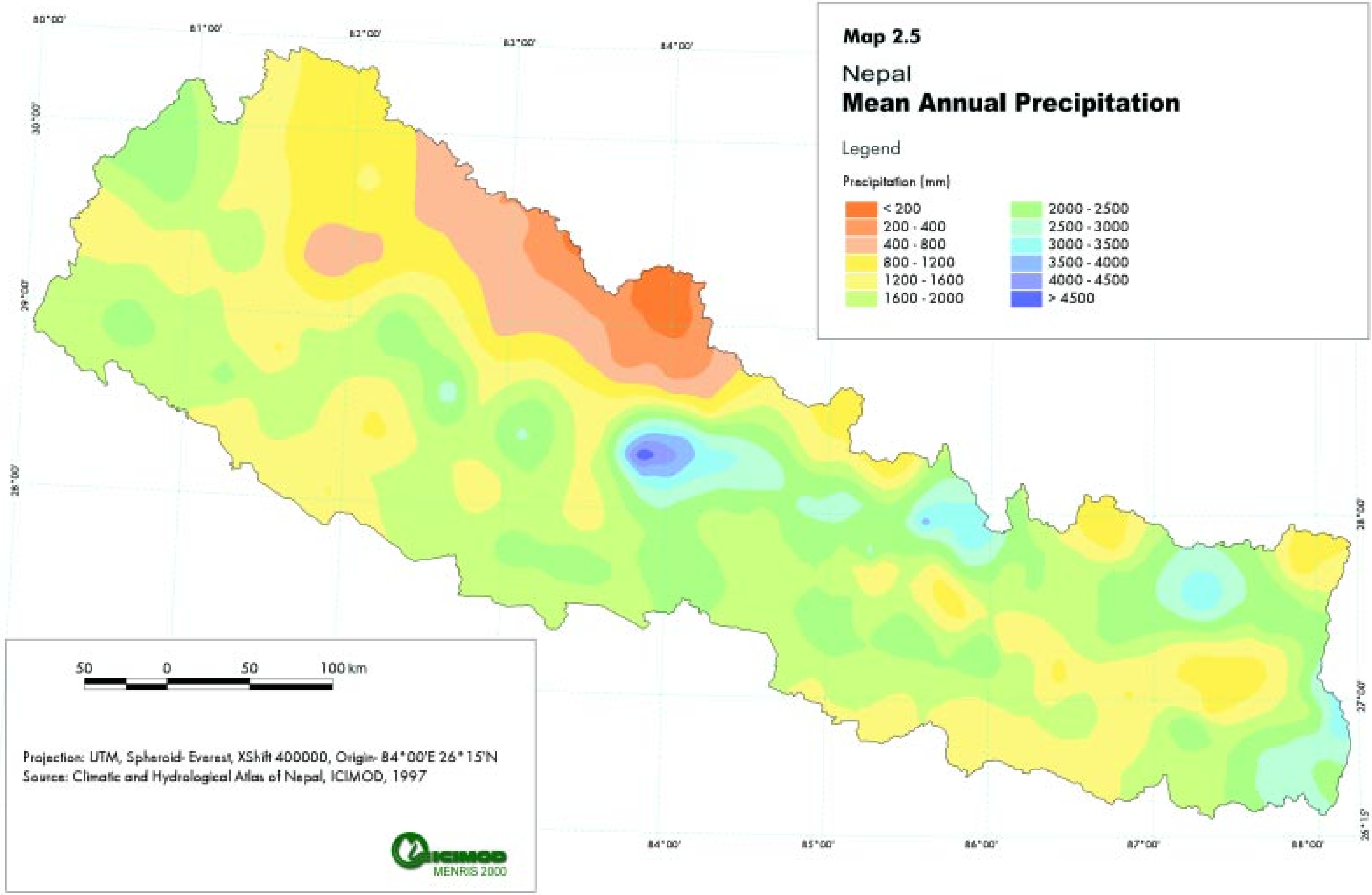


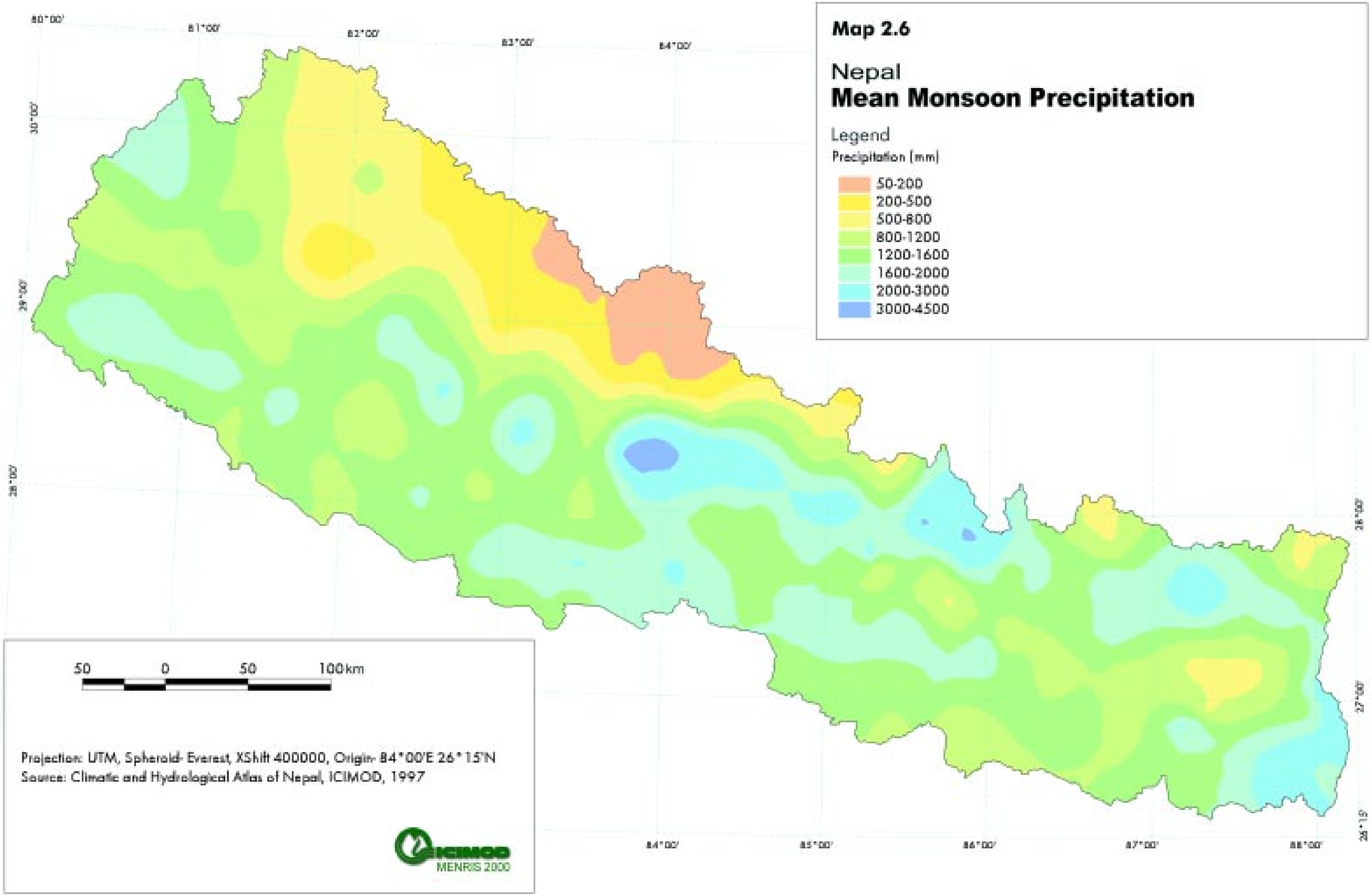
Map 2.3

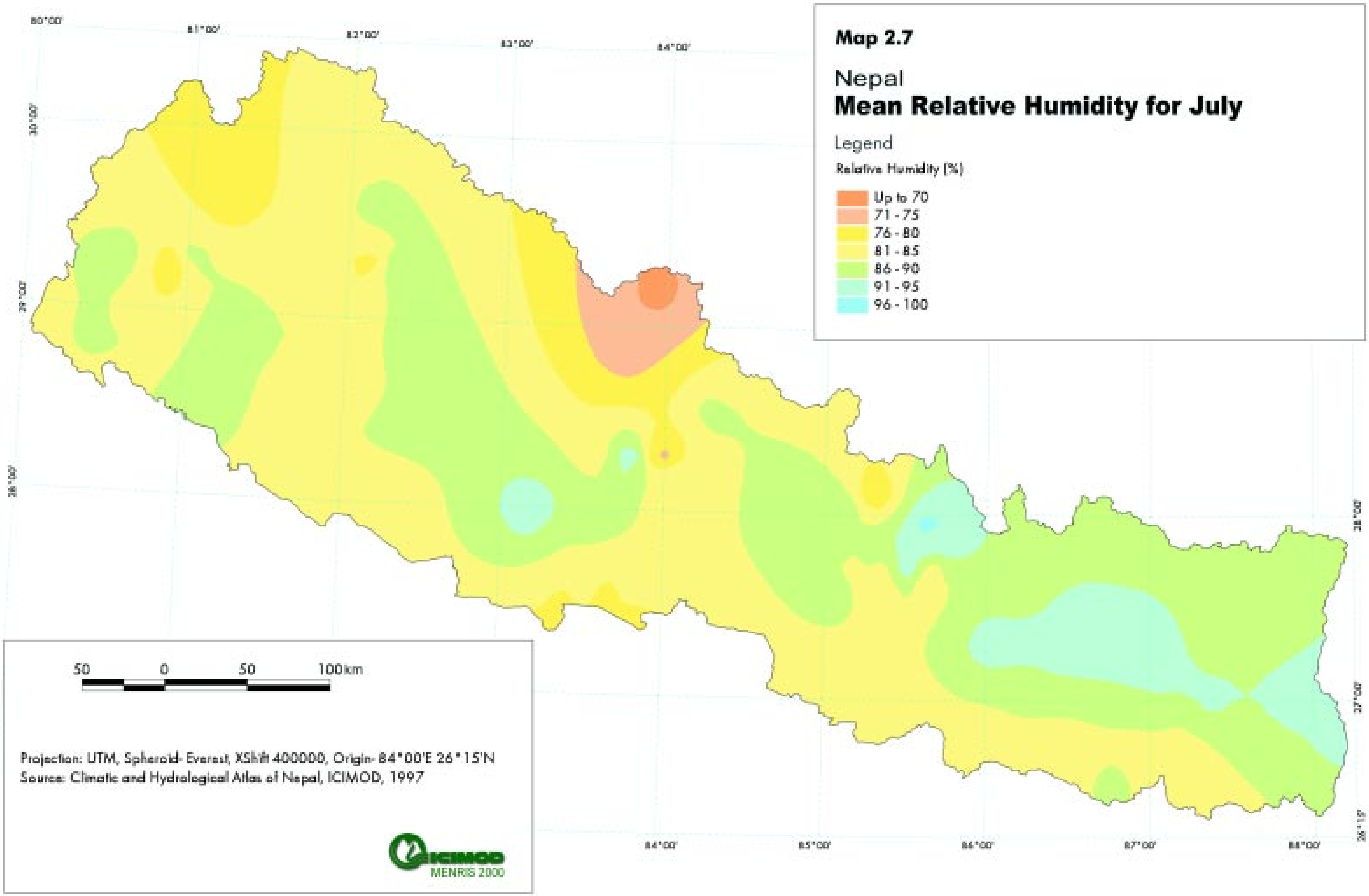
Nepal

Mean Temperature for July


Map 2.4
Nepal
Mean Temperature for January
Legend
Temperature (° Celsius)
< -3
-3 - 0
0 - 3
3 - 6
6 - 9
9 - 12
12 - 15
15 - 18
50 0 50 100km
Projection: UTM, Spheroid- Everest, XShift 400000, Origin- 84°00'E 26°15'N
Source: Climatic and Hydrological Atlas of Nepal, ICIMOD, 1997
ICIMOD
MENRIS 2000
80°00'
81°00'
82°00'
83°00'
84°00'
85°00'
86°00'
87°00'
88°00'
30°00'
29°00'
28°00'
27°00'
26°15'


Map 2.5
Nepal
Mean Annual Precipitation
Legend
Precipitation (mm)
< 200
200 - 400
400 - 800
800 - 1200
1200 - 1600
1600 - 2000
2000 - 2500
2500 - 3000
3000 - 3500
3500 - 4000
4000 - 4500
> 4500
80°00'
81°00'
82°00'
83°00'
84°00'
85°00'
86°00'
87°00'
88°00'
30°00'
29°00'
28°00'
27°00'
26°15'
50
0
50
100 km
Projection: UTM, Spheroid- Everest, XShift 400000, Origin- 84°00'E 26°15'N
Source: Climatic and Hydrological Atlas of Nepal, ICIMOD, 1997
MENRIS 2000


Map 2.6
Nepal
Mean Monsoon Precipitation
Legend
Precipitation (mm)
50-200
200-500
500-800
800-1200
1200-1600
1600-2000
2000-3000
3000-4500
50 0 50 100km
Projection: UTM, Spheroid- Everest, XShift 400000, Origin- 84°00'E 26°15'N
Source: Climatic and Hydrological Atlas of Nepal, ICIMOD, 1997
ICIMOD
MENRIS 2000


Map 2.7
Nepal
Mean Relative Humidity for July
Legend
Relative Humidity (%)
Up to 70
71 - 75
76 - 80
81 - 85
86 - 90
91 - 95
96 - 100
80°00'
81°00'
82°00'
83°00'
84°00'
85°00'
86°00'
87°00'
88°00'
30°00'
29°00'
28°00'
27°00'
26°15'
50
0
50
100km
Projection: UTM, Spheroid- Everest, XShift 400000, Origin- 84°00'E 26°15'N
Source: Climatic and Hydrological Atlas of Nepal, ICIMOD, 1997
ICIMOD
MENRIS 2000

Map 2.8

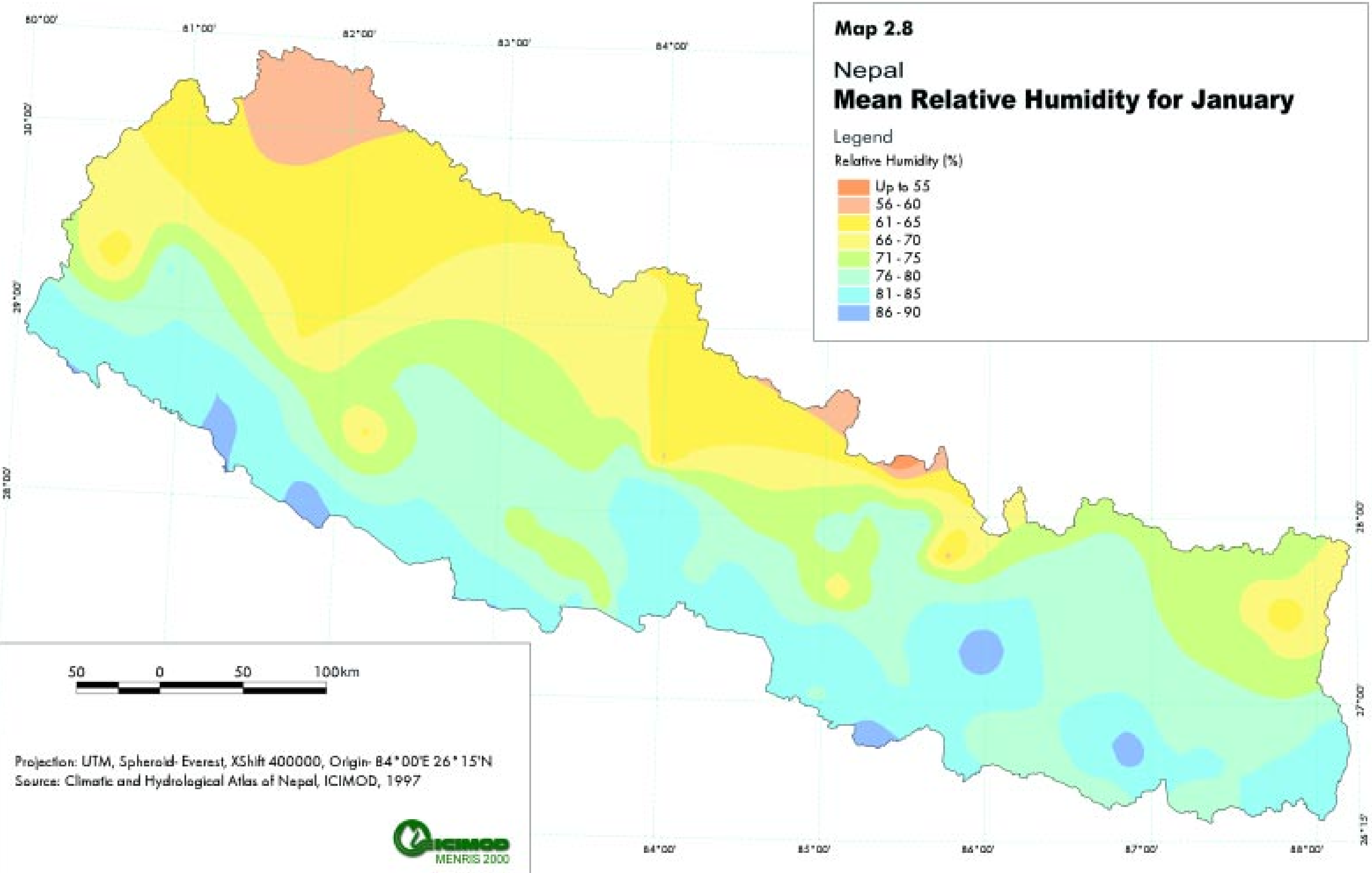
Nepal

Mean Relative Humidity for January

Legend

Relative Humidity (%)

- Up to 55
- 56 - 60
- 61 - 65
- 66 - 70
- 71 - 75
- 76 - 80
- 81 - 85
- 86 - 90



Projection: UTM, Spheroid- Everest, XShift 400000, Origin- 84°00'E 26°15'N

Source: Climatic and Hydrological Atlas of Nepal, ICIMOD, 1997

ICIMOD MENRIS 2000

2.2.9 Glacial lake outburst flood events

Apart from landslides and river erosion, the high mountains or Himalayas of Nepal are quite susceptible to land degradation caused by glacial lake outburst floods (GLOF). These mountains, which are 4,500 masl on average, are mostly covered with snow and ice throughout the year (about 15% of the country's total area). Since the second half of the twentieth century, the glacial environment of the high mountains has been experiencing rapid melting of its large glaciers, instigating the formation of a large number of glacial lakes. This may well be a result of global warming. Almost all of the glacial lakes of the Himalayas are formed by a glacier terminus dammed by moraine. These moraine-dams are not geologically consolidated enough to become a stable structure and therefore a slight disturbance can break the balance of the structure, resulting in an abrupt release of a great amount of water and generating floods. These floods can cause serious damage to infrastructure, houses, and the environment along the flood path downstream from the Himalayas. This phenomenon is called a 'glacial lake outburst flood' (GLOF).

In Nepal, GLOF events have been occurring for many decades, but this catastrophic glacier phenomenon came into the limelight only after 1985 when the Dig Tsho glacier outburst took place. Investigations into the nature of glacial lakes began in the country. In 1996, the Water and Energy Commission Secretariat (WECS) of Nepal reported five potentially dangerous lakes, namely, Dig Tsho, Imja, Lower Barun, Tsho Rolpa, and Thulagi, all lying above 4,100m. Their area extends from 0.6 to 1.39 sq.km. The maximum depth ranges from 81 to 131m, with ages above 30 years. A recent study done by ICIMOD/UNEP (2001) reported 27 potentially dangerous lakes in Nepal. In ten of them GLOF events have occurred in the past few years and some are regenerating after the event. This means activities have to be planned carefully in order to avoid artificial/human instigated triggering factors creating an outburst. A monitoring system for potential risk lakes should be established to avoid flood hazards.

2.2.10 Noise pollution

Noise pollution does not cause direct damage to the environment; however, like other sources of pollution, it can affect human health physically and psychologically, either by causing permanent hearing damage or by reducing efficiency in hearing in urban areas. Transportation is one of the predominant sources of noise pollution. Power tillers, buses, heavy trucks, and three-wheelers (tempos) are significant contributors to noise pollution in municipal areas. Old and poorly maintained automobiles (Sapkota et al. 1997) further aggravate noise pollution, causing significant health problems. Table 2.10 indicates the noise level of important places in Kathmandu. The reasons for excessive noise are inadequacy of mufflers fitted into vehicles, heavy traffic congestion, and use of horns.

Table 2.10: Noise level in decibels (dB) in different areas of Kathmandu

Areas	Noise Level Equivalent (N leq)	Noise level as % of samples			
		Nl_{10}	Nl_{50}	Nl_{95}	Nl_{max}*
High traffic	78.97	80.97	75.34	69.04	97.11
Low traffic	75.21	78.00	71.96	64.62	94.19
Public places	69.67	72.00	67.04	62.34	86.82
Residential and commercial places	74.52	77.02	70.44	63.38	92.27

Source: Sapkota et al. (1997)
* Note: Subscript values indicate sample size

The level of noise produced by industries depends on the types of machine and processes adopted. Out of 125 industries surveyed, noise levels were higher in the textile, cement, paper, marble, iron, steel, sugar, leather, and jute industries (NECG 1991). Miyoshi (1987) reported maximum values of 100 dB in some industries in Nepal: cloth, autoparts, metal works, cement (Kathmandu), steel (Biratnagar), and cement (Hetauda), and these exceeded international safety standards.

Noise is also on the increase in municipal and industrial areas. Although the impact of noise on human health has not been correlated, it is likely to be a major concern in the near future. This calls for the adoption of a stringent road traffic system, at least during peak hours, implementation of air and noise quality standards, and launching of awareness programmes on the impacts on human health.

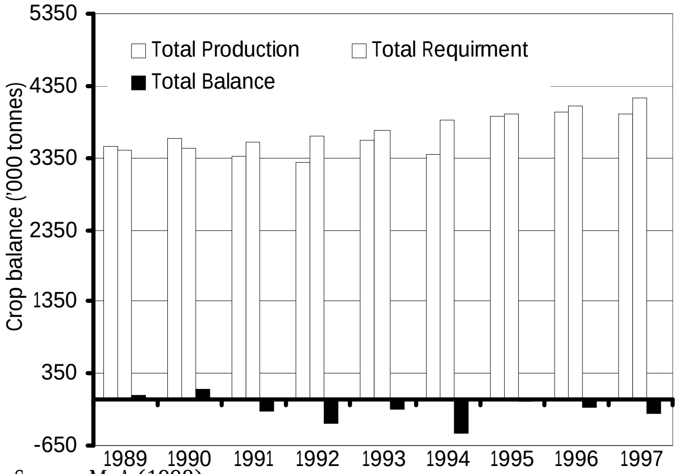
2.2.11 Food security

This section focuses mainly on two aspects: the overall quantity of food and its quality. Records of the former are available in the Ministry of Agriculture, while the Central Food Research Laboratory is responsible for monitoring the latter.

(a) Quantity of food

In 1994, the country experienced the greatest deficit in cereal production ever (by 485,000 tonnes) (Figure 2.2). However, the deficit was reduced in the following years. One limitation to increasing agricultural production is the lack of irrigation. The monsoon rain is not dependable, but without irrigation the agricultural system depends on it. About 28% of the total agricultural land of 2,968,000 hectares had access to irrigation in 1998 (MoA 1999), in 1984 it was only 13%.

Figure 2.2: Cereal grain production and requirement, Nepal



Source: MoA (1998)

(b) Quality of food

The quality of edible foods is regulated by the Food Act 2053 (1996). Its objectives are to safeguard the health and well being of consumers, to prevent adulteration of foodstuffs by undesirable elements, to prohibit change in the nature of any food, and to maintain quality.

As per the standards of the Food Act of Nepal, out of 739 samples inspected, about 20% were found to be substandard (Table 2.11).

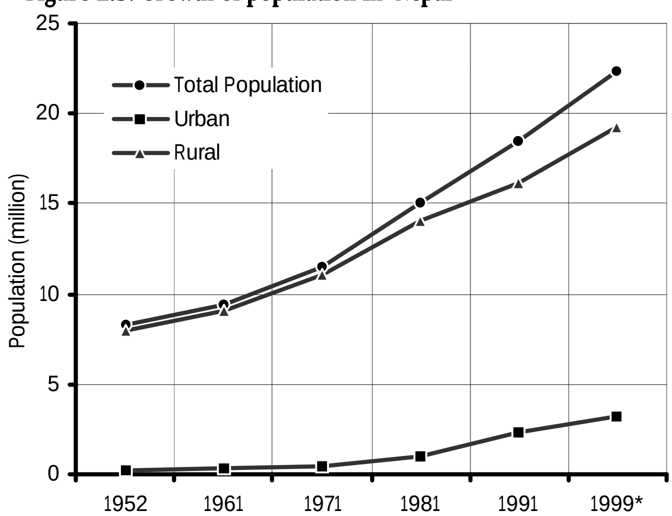
2.3 Social and economic driving forces

2.3.1 Population

One of the fundamental driving forces shaping the environmental resource base in Nepal is its population. The population increased from 8.473 million in 1952/54 to 18.491 million in 1991. The growth rate in population has remained above two per cent per annum since 1961. The population density increased from 102/km^2 in 1981 to 152/km^2 in 1998. Districts with a higher population density lie in the Terai region (Map 2.9). Map 2.10 shows the change in population by district from 1981 to 1991.

Since 1952, population growth in Nepal has been rapid. Nineteen eighty-one marks the beginning of a rapid growth in

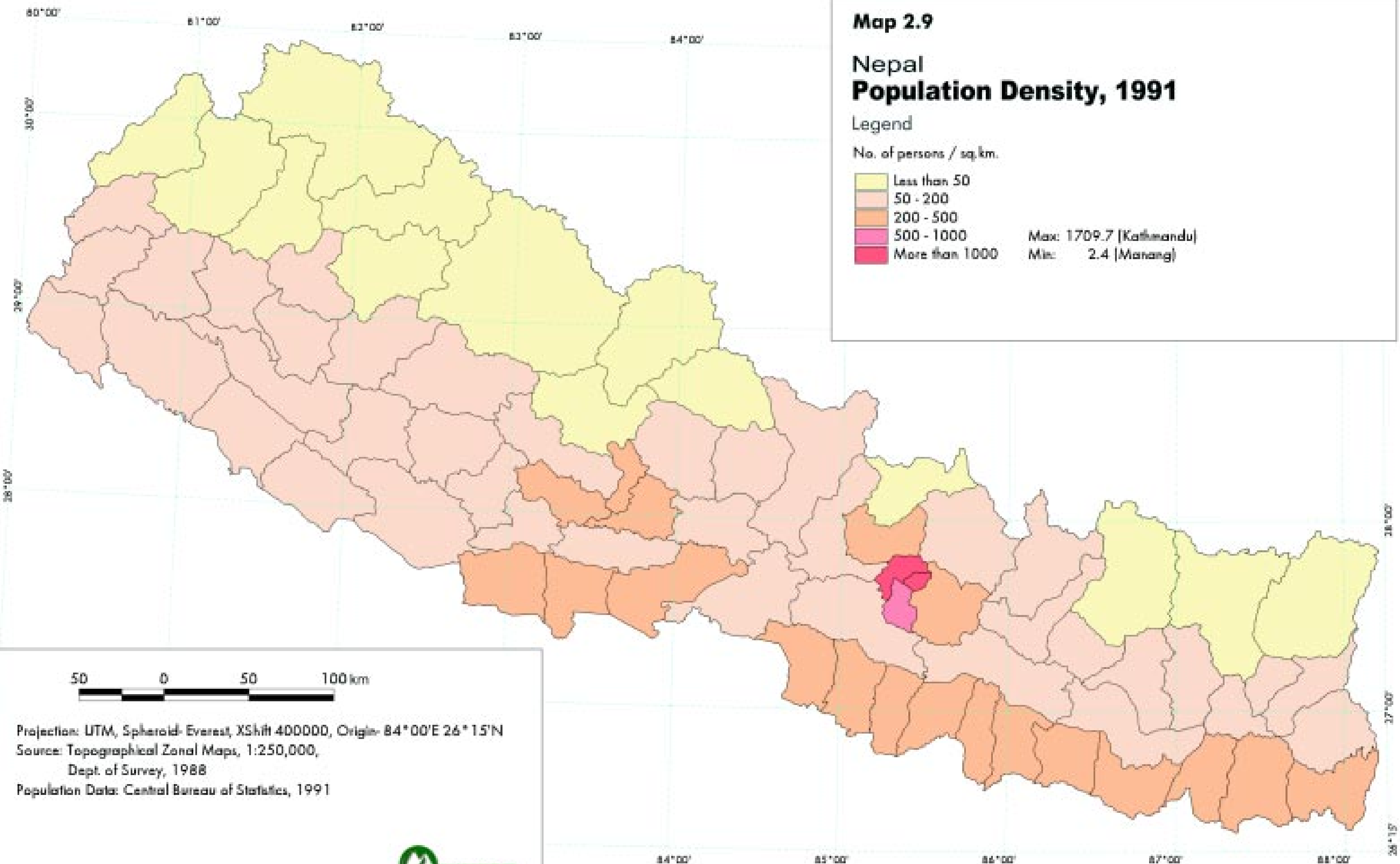
Figure 2.3: Growth of population in Nepal



Source: CBS (1999); CBS (1987)

Map 2.9

Nepal
Population Density, 1991



Legend

No. of persons / sq.km.

- Less than 50
- 50 - 200
- 200 - 500
- 500 - 1000
- More than 1000

Max: 1709.7 (Kathmandu)
Min: 2.4 (Manang)

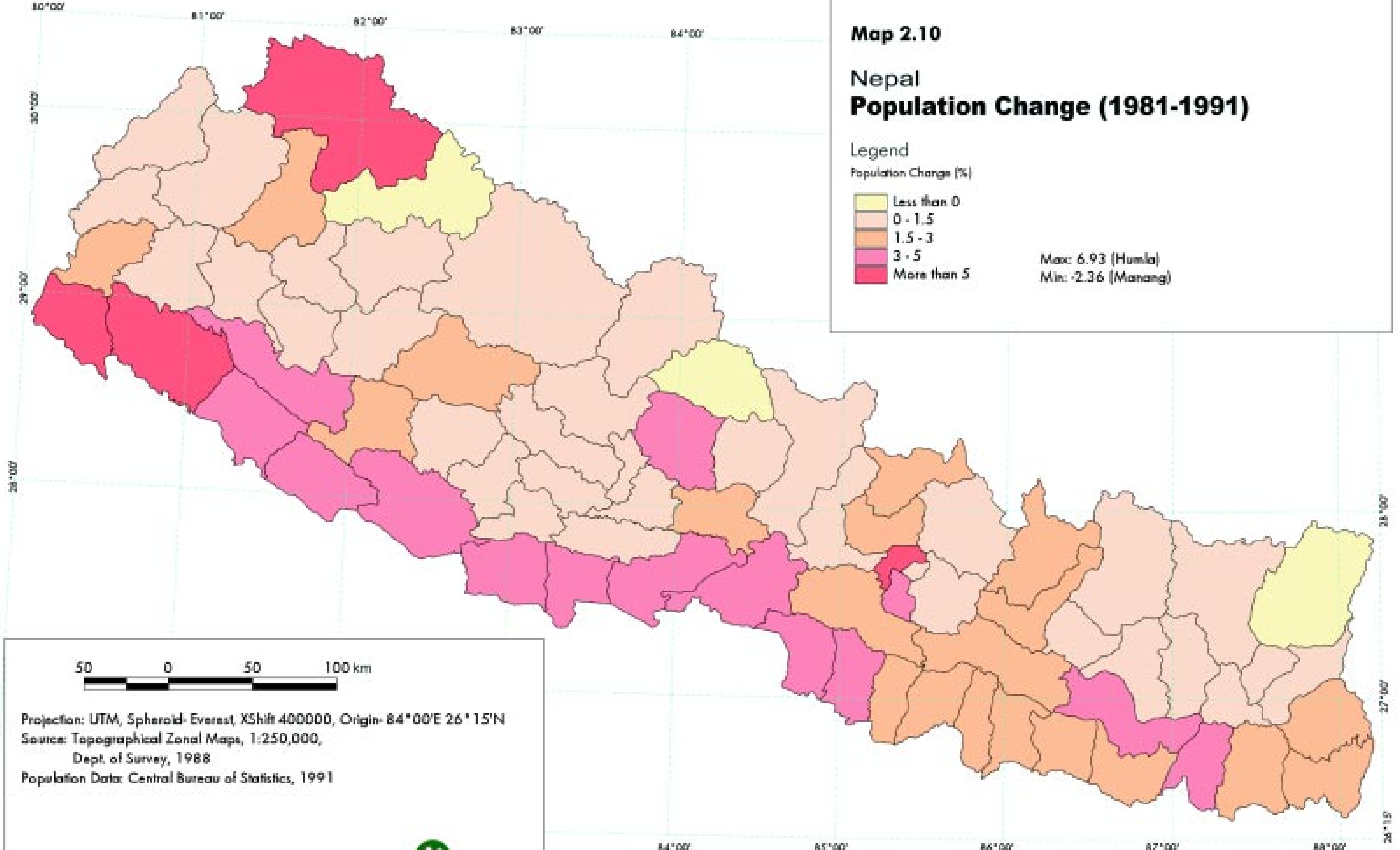
50 0 50 100 km

Projection: UTM, Spheroid- Everest, XShift 400000, Origin- 84°00'E 26°15'N
Source: Topographical Zonal Maps, 1:250,000,
Dept. of Survey, 1988
Population Data: Central Bureau of Statistics, 1991

ICIMOD MENRIS 2000

Map 2.10

Nepal
Population Change (1981-1991)



Projection: UTM, Spheroid- Everest, XShift 400000, Origin- 84°00'E 26°15'N
Source: Topographical Zonal Maps, 1:250,000,
Dept. of Survey, 1988
Population Data: Central Bureau of Statistics, 1991

ICIMOD MENRIS 2000

Table 2.11: Quality of food items in the Kathmandu Valley

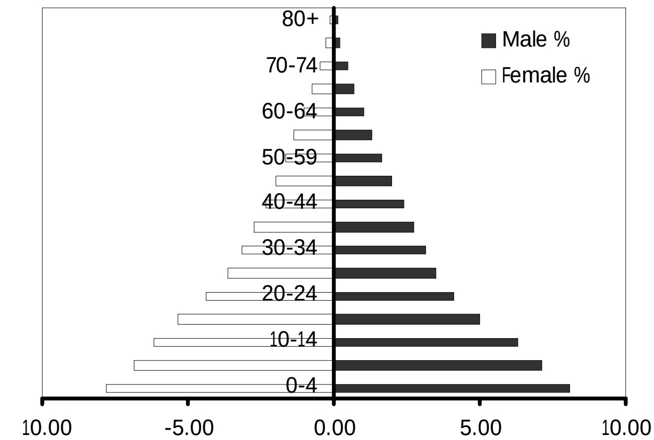
Food/feed commodities	Number of samples/ adulterated cases	Type of adulteration
Edible oils	43/14	Mostly rapeseed oil, some linseed oil and some soybean oil with high free fatty acid
Ghee	17/12	Vegetable ghee, palm oil with high free fatty acid and [annatto] colour present in one sample
Milk products	25/5	Coliform contamination; fat % and solid non fat % low
Fruit products	64/10	Total soluble solid low
Spices	114/9	Foreign matter; volatile oil low
Tea	25/1	Caffeine low
Biscuits	75/2	Moisture high and acidity of extracted fat high
Salt	5/4	Iodine content high
Cereals	98/4	Heat and fungus damaged grains; use of artificial colour in pulses
Sweets, mineral water, etc	236/78	Sweets with non-edible colour; mineral water with high pH value and contaminated with yeast and mould
Total	739/150	20% violated

Source: Joshi (2000)

population, both rural and urban (Figure 2.3). This growth has put tremendous pressure, directly and indirectly, on the available natural resources in the country. The population is expected to reach 24 million by 2008.

- The economically active population above 10 years of age constituted almost 57% of the total population in 1991, down from 65% in 1981. The proportion of gainfully employed population in the 15-59 age group has declined in successive census years (CBS 1999). The large base of a young dependent population, as shown in Figure 2.4, indicates that there is great dependency on a relatively low proportion of active population.
- In 1981, the population gainfully employed constituted nearly 46%. There was a relative decline in the population gainfully employed in 1991 to slightly below 40%. Agriculture is the dominant occupation of the economically active population above 10 years of age. Table 2.12 shows that the proportion of the population employed in agriculture declined from nearly 91% in 1981 to 81% in 1991. In other sectors, the proportion of gainfully employed population increased.
- In 1997, out of the economically active labour force of 11.67 million, 4.9% were completely unemployed (MoF 1999). Of the employed labour force, 81% was engaged in the agricultural sector and the remaining 19% in industry, mines, electricity, construction, trade, hotels, transport, communications, finance, real estate, and the community and social sectors. Note that 47% of the

Figure 2.4: Population pyramid



Source: CBS (1999)

total employed labour force was found to be semi-employed and that a majority of it was in the agricultural sector. It is estimated that about 300,000 persons enter the labour market every year (MoF 1999).

- The total fertility rate (TFR) has declined remarkably. In 1971, the TFR was 6.3. It declined to 6.0 in 1986 and further declined to 4.6 in 1996.
- The crude birth rate has improved, between 1981 and 1999 it declined from 44.9 to 34.1 persons per 1000 (Table 2.13). The crude death rate declined from 13.5 in 1981 to 10.3 persons per 1,000 in 1999. The average annual growth rate of the population has remained above two per cent since 1981. The density of population increased in each successive census year from 102/km^2 in 1981 to 152/km^2 in 1999.
- Interestingly, Table 2.13 shows that both rural and urban populations have increased in Nepal. The rural population density increased progressively in successive census years; the urban population density did not, but the number of municipalities increased from 23 in 1981 to 58 in 1998. The average annual growth rate of the urban population has been much higher than that of the rural population since 1952. The average annual growth rate of the urban population in 1952/54 was 4.51% compared to 1.22% for the rural population: in 1991 the values were above 7 and below 2%, respectively. The 58 municipalities have been categorised into three levels: metropolitan, sub-metropolitan, and municipal. Of these, one is a metropolitan city and four are sub-metropolitan cities.
- The overall development level measured by the development index varied greatly among the districts of Nepal (Map 2.11).

Table 2.12: Proportion of economically active population above 10 years of age

Economic sector	Total population %	
	1981	1991
Agriculture, fisheries and forestry	90.75	81.23
Mining and quarrying	0.01	0.03
Manufacturing	0.48	2.04
Electricity, gas and water	0.48	0.16
Construction	0.03	0.49
Trade, restaurants and hotels	1.59	3.49
Transport, communication and storage	0.11	0.69
Finance and real estate	0.14	0.28
Community and social services	4.56	10.25
Others	0.00	0.38
Unidentified sectors	1.85	0.96

Source: MOF (1998)

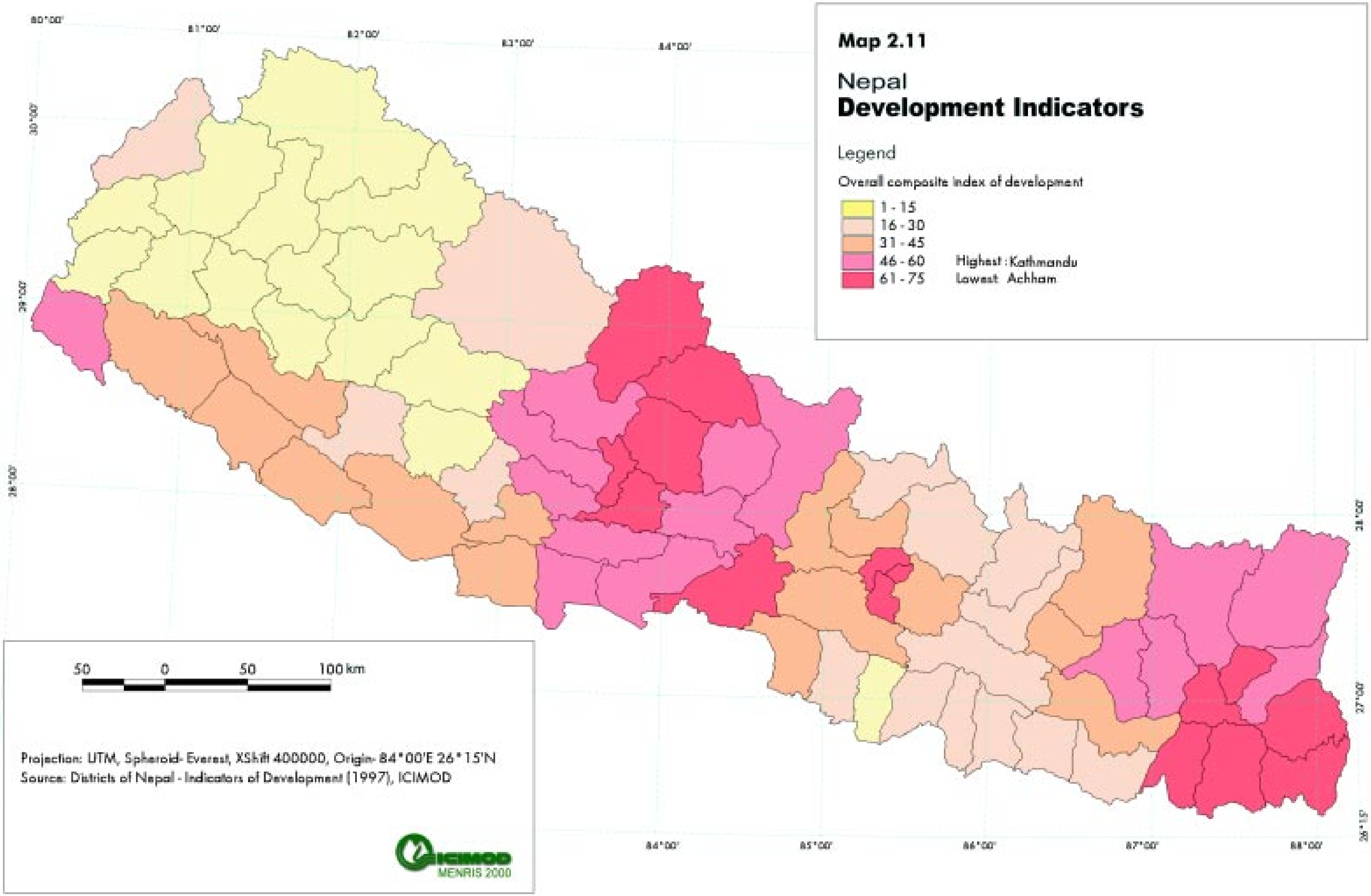
Table 2.13: General population characteristics

Population parameters	1981	1985	1990	1995	1999
Crude birth rate (number/1000 population)	44.9	43.0	39.6	37.5	34.1
Crude death rate (number/1000 population)	13.5	16.0	14.8	13.8	10.3
Population density (number/km²)	102	113	128	138	152
Average annual population growth rate (%)	2.66	2.64	2.57	2.38	2.37
Rural population (million)	14.07	15.52	17.38	17.95	19.2
Urban population (million)	0.95	1.16	1.5	2.07	3.17*
Rural population density (number/km²)	96	106	119	123	136
Urban population density (number/km²)	1011	1234	1347	1467	527

Source: SEAMCAP (2000)
* 22 new municipalities declared and area of some others increased

2.3.2 Tourism

One of the economic and social developments of Nepal with the most potential is tourism. Nepal has been a destination for tourists because of its cultural, social, and natural uniqueness. Since the opening of the kingdom to foreigners in 1956, tourist visits to the country have increased tremendously. In 1999 there were almost 500,000 tourist arrivals, almost five times that of 122,200 in 1980 (Figure 2.5).


Map 2.11
Nepal
Development Indicators
Legend
Overall composite index of development
1 - 15
16 - 30
31 - 45
46 - 60
61 - 75
Highest : Kathmandu
Lowest Achham
50 0 50 100 km
Projection: UTM, Spheroid- Everest, XShift 400000, Origin- 84°00'E 26°15'N
Source: Districts of Nepal - Indicators of Development (1997), ICIMOD
ICIMOD
MENRIS 2000

Though the number of tourist arrivals has increased, the annual ratio change has decreased from a 48% increase between 1980 and 1985 to a 42% ncrease between 1990 and 1995 (Figure 2.5). The total number of tourist arrivals increased from 255,000 in 1990 to 363,000 in 1995 and 491,500 in 1999 (MoF 1999).

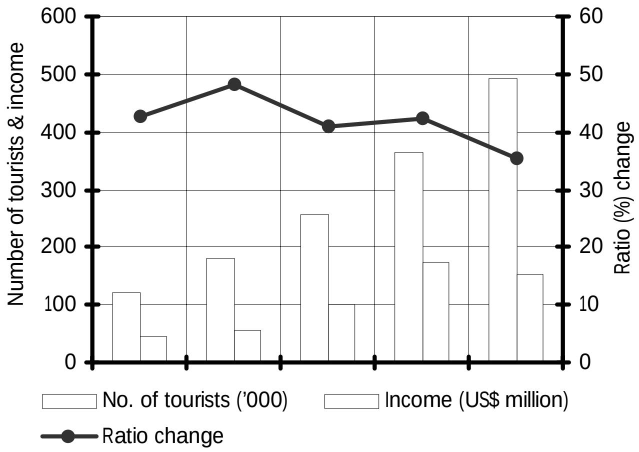
Tourism is a major source of foreign earnings. Foreign earnings have increased along with the increase in international tourist arrivals. But due to the devaluation of the Nepalese rupee against the US dollar, earnings from tourism decreased between 1995 and 1999. In 1999, the tourism sector accounted for almost 16% of the total foreign exchange earnings in the country (MoF 2000).

Tourism has many facets in terms of employment generation. As a result of tourist growth, the number of hotels of different standards and their dependent activities like restaurants, groceries, curio, and other shops, have increased to a great extent. However, tourism is largely characterised by its seasonal feature. Two seasonal periods from Sep-Nov and Feb-Apr are very important in terms of tourist arrivals, mainly due to pleasant weather conditions (Figure 2.6).

2.3.3 Roads

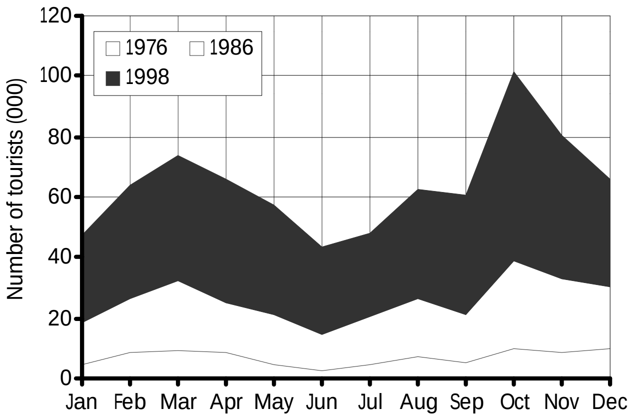
The state of roads is described in terms of total length with respect to area and population. The total road length in 1998 was 13,400 km compared to 6,000 km in 1985. Of the total road length of 10,724 km in 1995 the Terai has over 50% and the Mountain region only 4% Figure 2.7. With 2,831 km, the highways appear to be inadequate and have not yet connected to all the district headquarters of Nepal. One km of road serves 1,630 persons or an area of 10.98 sq.km. In other words, there are 6.1 km of road for every 10,000 people, or 9.1 km of road in an area of 100 sq.km. The Terai appears to be the most accessible region in terms of road accessibility, measured by population size

Figure 2.5: Tourist arrivals and income



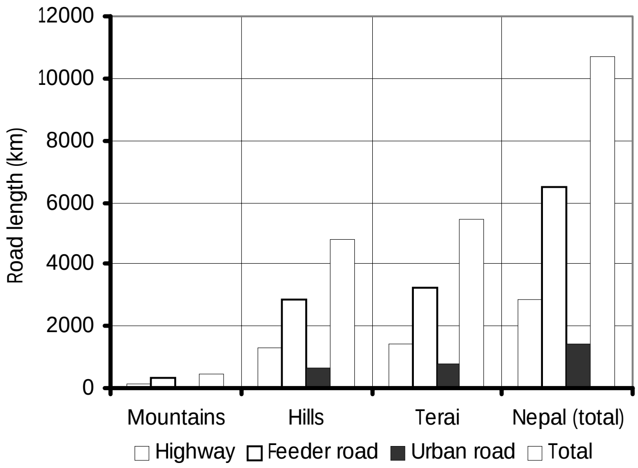
Source: CBS (1999); MoF (1999)

Figure 2.6: Tourist arrival pattern



Source: CBS (1987, 1999)

Figure 2.7: Road type by ecological belt



Source: DoR (1998)

and area. On the other hand, many parts of the Hill and Mountain regions are not accessible by road (Map 2.2).

2.3.4 Health services status

The health services status in Nepal, as measured in terms of health service units (hospitals, health centres, health posts, and ayurvedic centres) by area and population, is very uneven between urban and rural areas and among geographical regions (Table 2.14). Overall, one health service unit covers an area of 3.3 sq.km or serves 4,169 persons. The Terai region is relatively the most accessible in terms of health services, with one health unit for each 2.7 sq.km of area, whereas the Mountain region is the least, where one health service unit covers 5.7 sq.km. Conversely, the available health services in the Terai region bear the greatest pressure in terms of coverage of population, while those in the Mountain region have the least.

Table 2.14: Health services status in Nepal, 1997

Physiographic region	Number of health service units	Population/ health service	Area sq.km/ health service
Mountain	620	2,336	5.7
Hill	2,323	3,642	3.1
Terai	1,503	5,741	2.7
Total	**4,446**	**4,169**	**3.3**

Source: DOHS (1999)

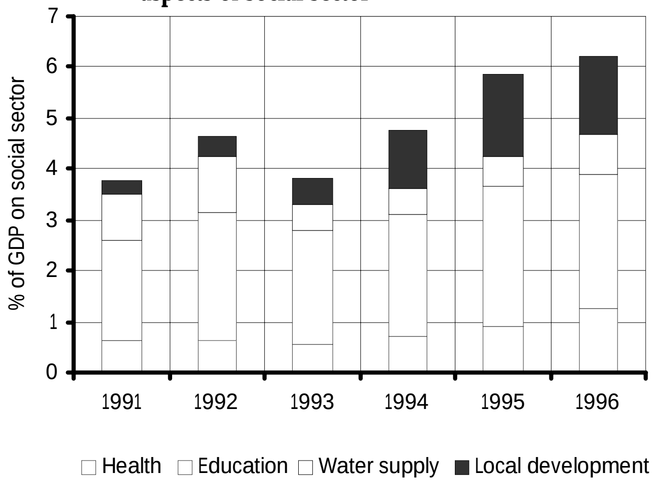
Table 2.15: Health accessibility in Nepal

Description	1991	1995	1998
Population ('000) per physician	12.5	23.3	23.7
Health service units ('000)	1.3	3.7	4.4
Population ('000)/health service	13.9	5.5	5.0
Population ('000) per bed	3.8	5.2	3.0

Source: CBS (1993, 1997, 1999)

- There is increasing pressure on the available physicians. The number of physicians has increased each year successively, but the rate of growth in population, as shown in Table 2.15, means that there are still too few. The same is the case for health service units.
- The proportion of gross domestic product (GDP) spent on the social sector has increased in all years except in 1993, and likewise that for health services (Figure 2.8). Education has received the largest share of the total social sector expenditure. Total annual expenditure on health education also increased to US$ 2,226,000 in 1999 (0.05% total GDP) up from US$ 1,305,000 in 1995 (0.02% GDP). The proportional share of GDP for the whole education service has also increased, whereas that for drinking water supply has decreased. The increase in share of GDP for local development means improvement of infrastructural development in both rural and urban areas.

Figure 2.8: Relative share of GDP expenditure by different aspects of social sector



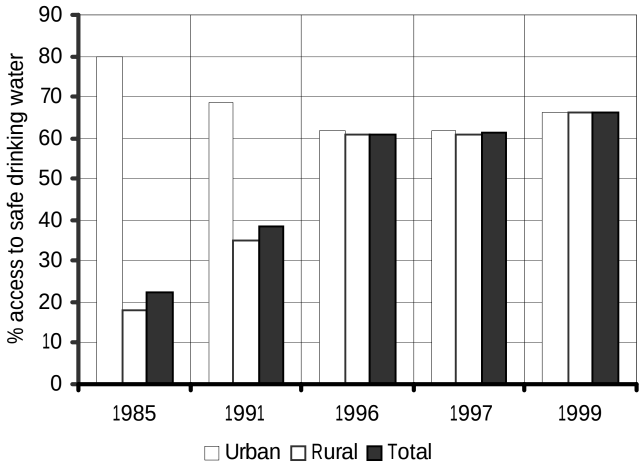
Source: MoF (1998) *(Total GDP in billion $US)

- In Nepal, the access of people to general sanitation and safe drinking water has improved in recent years. Figure 2.9 shows that access to safe drinking water in rural areas has increased tremendously but that in urban areas it has decreased compared to 1985 and 1991. Access to sanitation facilities has also increased from 6% in 1991 to 25% in 1999. There is a marked variation in access to sanitation between rural and urban areas. In the urban area, it was 34% in 1991 and increased to 67% in 1999, while in the rural area it was 3 and 18% in 1991 and 1999, respectively (NPC 1992; NPC 1997; RWSSP 1996; RWSSP 1999).

2.3.5 Pattern of accessibility to basic facilities

- The pattern of accessibility to basic facilities such as schools, health, cooperatives, agricultural service centres, banks, and bus stops between urban and rural areas is depicted in Table 2.16. Compared to urban areas, the travelling times for households in rural areas to reach given facilities are higher as is the distance travelled. In other words, a majority of households living in urban areas lies within a convenient time and distance to reach given facilities. In rural areas a considerable proportion of households generally take a longer time to get to basic rural development facilities such as health posts, cooperatives, agricultural centres, and commercial banks.

Figure 2.9: Access to safe drinking water



Source: NPC (1992, 1997); RWSSP (1996, 1999)

Table 2.16: Pattern of household accessibility to basic facilities (%)

Facilities	≤ 0.5 hour		0.5 -1 hour		1-2 hours		2-3 hours		≥ 3 hours	
	Urban	Rural	Urban	Rural	Urban	Rural	Urban	Rural	Urban	Rural
Primary school	97.4	87.73	2.11	8.41	0.49	2.99	0	0.37	0	0.5
Health post	88.7	41.33	10.36	26.1	0.94	19.29	0	8.26	0	5.03
Cooperative	85.39	21.15	12.56	19.87	1.67	24.78	0.09	13.93	0.29	20.27
Agricultural centre	80.54	19.94	17.43	20.17	1.75	26.15	0.09	14.93	0.19	18.81
Commercial bank	89.77	15.23	8.92	18.4	1.22	26.63	0.09	17.07	0	22.67
Bus stop	89.44	28.42	9.46	15.73	0.99	17.24	0	12	0.1	26.6

Source: CBS (1998)

- Based on income distribution, employment, and consumption patterns (MoF 1999), the Ninth Plan (1997-2002) indicated that 42% of the total population was below the poverty line, of which 24.9% and 17.1% were poor and very poor, respectively. The rural area is much more poverty stricken with 44% compared to 23% in the urban area. The poverty rate, i.e., 42% of the total population, is worse than in previous years. In 1978, the proportion of population below the poverty line was 36%, it rose to 41.5% in 1985 and further to 49% before the beginning of the Eighth Plan (1992-97).
- The national economy relies heavily on agriculture. But growth in the agricultural sector is squarely dependent on weather conditions because of the lack of adequate agricultural infrastructure for proper irrigation. When the agricultural sector is in a bad situation, other sectors are also affected. Due to bad weather conditions, the growth in GDP in the agricultural sector was 1% in 1997 compared to 4.1% in 1996 under normal weather conditions.
- During the fiscal year 1997/98, the estimated contribution of the agricultural sector to the GDP was 40.3% and that of the non-agricultural sector was 59.7%. It was estimated that the growth in agricultural and non-agricultural sectors for the fiscal year 1998/99 would be 2.4 and 4.1% respectively (MoF 1999).
- The ratio of savings to gross national income in Nepal is less than that of other Asian developing countries. During the fiscal year 1997/98, the ratio of gross domestic savings to

GDP at current prices stood at 9.5%. The preliminary estimate for the fiscal year 1998/99 was 10.6%. The ratio of gross domestic investment to GDP for the fiscal years 1997/98 and 1998/99 stood at 20.7and 17.3% respectively. Thus, the savings differences in percentage for the two fiscal years were 11.2 and 6.7% respectively (MoF 1999).

- The overall development level measured by the development index varied greatly among the districts of Nepal (Map 2.11).

2.4 Prioritisation of significant environmental issues

The significant environmental issues (SEI) were categorised into three levels based on the information obtained from the expert questionnaire survey (Table 2.17).

Table 2.17: Prioritisation of significant environmental issues

Most urgent *	**Moderately urgent**	**Less urgent but still significant**
• Depleting forest • Degrading land • Solid waste management • Water pollution • Air pollution	• Dwindling biodiversity • Desertification • Haphazard urbanisation • Forest fire • Groundwater depletion • Glacial lake outburst flood events • Food security • Alternative energy	• Waning fisheries • Decreasing biomass energy • Transboundary movement of wastes • Noise pollution
* The first two issues are basically associated with the rural and the latter three with the urban area.		

References

Boden, T.A.; Marland, G.; Andres, R.J. (1995) *Estimates of Global, Regional and National Annual CO_2 Emission from Fossil Fuel Burning, Hydraulic Cement Production and Gas Flossing: 1950-1992*. Oak Ridge : USDOE, Oak Ridge National Laboratory, Carbon Dioxide Information Analysis Center

BPP (1995) *An Enumeration of Mammals of Nepal*. Kathmandu: DNPWC/BPP

CBS (1985) *A Statistical Year Book of Nepal*. Kathmandu: CBS

CBS (1993) *A Statistical Year Book of Nepal*. Kathmandu: CBS

CBS (1994) *A Compendium of Environmental Statistics in Nepal*. Kathmandu: CBS

CBS (1997) *A Statistical Year Book of Nepal*. Kathmandu: CBS

CBS (1998) *A Compendium of Environmental Statistics, 1998*. Kathmandu: CBS

CBS (1999) *A Statistical Year Book of Nepal*. Kathmandu: CBS

CBS (2000) *A Statistical pocket Book of Nepal*. Kathmandu: CBS

Devkota, S.R (1992), *Energy Utilization and Air Pollution in the Kathmandu Valley Nepal*. M.Sc. Thesis. Bangkok: Asian Institute of Technology

DFRS (1999) *Forest and Shrub Cover of Nepal 1994*. Kathmandu: DFRS

DHM (1998) *Record File of TSP in Kathmandu Valley*. Kathmandu: DHM

DHM (1998a) *Hydrological Records of Nepal: Stream Flow Summary*. Kathmandu: DHM

DoHS (1999) *Annual Report 1998/99*. Kathmandu: DoHS

DOT (2000) *Number of Vehicles Registered*. Kathmandu: Office Record of the Department of Transport Management (Personal Communication)

DPR (1997) *Flora of Nepal: Management Document*. Kathmandu: DPR

DPR (1999) *Working Guidelines*. Kathmandu: DPR

DPTC (1997) *Annual Disaster Review 1996***.** Kathmandu: Water Induced Disaster Prevention Centre

FSD (1999) *Forest and Shrub Cover of Nepal, 1994*. Kathmandu: DFRS/FSD

HMG/FINNIDA/ADB (1988) *Master Plan for Forestry Sector: Main Report*. Kathmandu: HMG/ FINNIDA/ADB

ICIMOD (2000) *Land Use Change*, unpublished report. Kathmandu: ICIMOD/MENRIS

ICIMOD/UNEP (2001) *Glaciers and Glacial Lakes of Nepal*, (in preparation). Kathmandu: ICIMOD

JICA/DHM (1993) *The Study on Nationwide Hydro-Meteorological Data Management Project* (*Main Report).* Kathmandu: HMG, DHM/JICA

Joshi, U. (2000) *Ensuring Food Safety in the Kathmandu Valley,* 10th Anniversary Souvenir. Kathmandu: ENPHO

MFSC (1997) *National Report on the Implementation of the Convention on Biological Diversity*. Kathmandu: MFSC

Miyoshi, Y. (1987) *Report on Industrial Pollution Control.* Kathmandu: Industrial Service Centre

MoA (1999) *Statistical Information on Nepalese Agriculture, 1998/99***.** Kathmandu: MoA

MoF (1998) *Economic Survey*. Kathmandu: MoF

MoF (1999) *Economic Survey*. Kathmandu: MoF

MoF (2000) *Economic Survey*. Kathmandu: MoF

MoHA (1999) *Loss of Lives by Disasters (1983-1999).* Kathmandu: MoHA, Disaster Relief Section

MoPE (2000) *State of the Environment Report*. Kathmandu: MoPE

NAA (1995) *Plant Genetic Resources Profiles Study*. Kathmandu: NAA/JICA

NEA (1999) *Annual Review of Electricity*. Kathmandu: NEA

NECG (1991) *Industrial Pollution Survey in Nepal.* Kathmandu: Nepal Environmental Conservation Group/NPC/IUCN

NPC (1992) *The Eighth Plan (1992-1997)*. Kathmandu: NPC

NPC (1997) *The Ninth Plan (1997-2002)*. Kathmandu: NPC

Pandey, M.R.; Regmi, H.N.; Neupane R.P.; Gautam, A; Bhandari, D.P. (1985) *Domestic Smoke Pollution and Respiratory Function in Rural Nepal*. Yokai J. Exp. Clin. Med. 10: 471-481

RWSSP (1996), *Report of Rural Water Supply and Sanitation Project* (unpublished). Kathmandu: Department of Water Supply

RWSSP (1999), *Report of Rural Water Supply and Sanitation Project* (unpublished). Kathmandu: Department of Water Supply

Sapkota, B.K.; Pokhrel, B.; Poudyal, K.; Bhattarai, B. (1997) 'Noise Pollution in Kathmandu'. In *Journal of Environment*, pp56-64. Kathmandu: MoPE

SEAMCAP (2000) *State of Environment Dataset Report Nepal: Strengthening Environment Assessment and Monitoring Capabilities in Nepal*. Kathmandu: UNEP/ MoPE/ICIMOD (in preparation)

Shrestha, J. (1995) *An Enumeration of Fishes of Nepal*. Kathmandu: DNPWC/BPP

Shrestha, T.B.; Joshi, R.M. (1996) *Rare, Endemic and Endangered Plants of Nepal*. Kathmandu: WWF-Nepal Program

Thapa, V.K. (1995) *An Enumeration of Insects of Nepal*. Kathmandu: DNPWC/BPP

Thapa, V.K. (1997) *An Inventory of Nepal's Insects, Volume I. Biodiversity Publication*. Kathmandu: IUCN

UNDP (1998) *Nepal Human Development Report*. Kathmandu: UNDP/Nepal South Asia Centre

Uprety, B.K. (1998) 'Natural Biodiversity', In *Environmental Statistics 1998: Nepal*. Kathmandu: CBS

WECS (1996), *Energy Synopsis Report, Nepal 1994/95.* Kathmandu: MoWR/WECS

WECS (1997) *WECS Bulletin,* 8(3)

WECS (1999) *WECS Bulletin***,** 10(1 and 2)

Part III
Key Issues

3.1 FOREST DEPLETION

3.1.1 Introduction

The forests of Nepal are the second largest natural resource after water. However, during the last four decades, the forest area has decreased considerably due to uncontrolled use of forests and their products. Compared to 6.4 million hectares of forest in 1964, the current forest area is 4.27 million hectares: 29% of the country's total area (DFRS 1999a). Between 1978 and 1994, the rate of deforestation in the country was 1.7% per year. Thus, forest depletion has emerged as one of the most serious environmental issues for Nepal. Forest depletion has brought about many other environmental impacts such as landslides, soil erosion, floods, soil degradation, out-migration of people, and so on. Thus, conservation of the forest resource is fundamental to the protection of other resources such as water, soil, flora and fauna, and human activities such as agriculture, animal husbandry, and logging which are directly and indirectly dependent on it.

Diminishing forest area can be attributed primarily to the rapid growth of population. The number of people dependent on agriculture is rising; and as a result agricultural land has increased, mostly by encroaching upon forest areas. One of the major challenges faced by the country is how to conserve forest resources. Some programmes, such as community forestry programmes, have carried out exemplary work on conserving forest resources. But, on the other hand, there are also activities responsible for the dwindling of forest resources in the country. It is important in this context to understand the status of forest resources in terms of use and misuse, measures undertaken to conserve the forests, and programmes laid down for the future by the national government. However, the forest data available are characterised by being both scanty and scattered.

3.1.2 Pressure

The forest, according to the Department of Forest Research and Survey (DFRS 1999b), refers to all land having trees with more than 10% crown cover and not used primarily for purposes other than forestry. This also includes temporarily cut forest area. Forest depletion refers to the diminishing of forests in terms of quantity and quality. Quantity refers to the gross area covered by the forest whereas quality signifies the density of trees in the forest area.

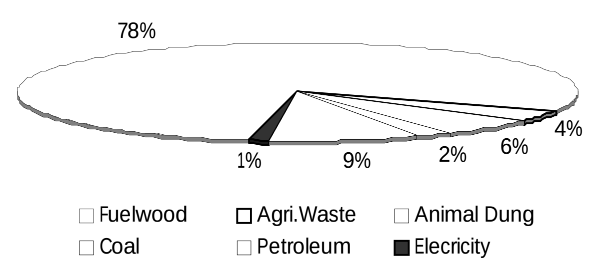
(a) Population Growth

The population is growing at a rapid rate; the growth rate has remained at over two per cent per annum since 1961. Population growth appears to be the single most important factor behind diminishing forest resources in the country.

(b) Types of energy used

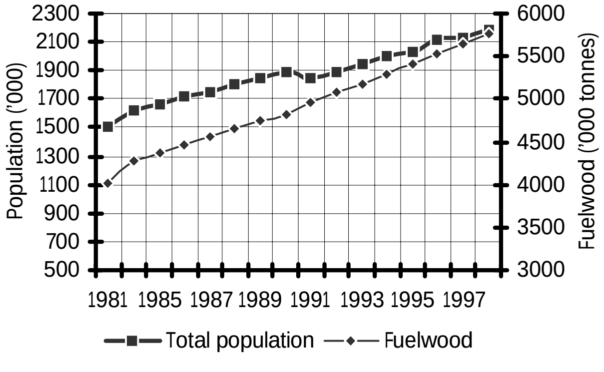
Figure 3.1 shows that the energy consumption of Nepalese people is excessively dependent on fuelwood. In 1998, fuelwood derived from the forest constituted the largest proportion of the total fuel consumption (78%). Along with the increase in population, the consumption of fuelwood, as shown in Figure 3.2, has also increased. The fact is that, in the absence of alternative energy sources, most rural

Figure 3.1: Consumption of energy by type (Total energy used:7,340,000 toe in 1997/98)



Source: WECS (1999)

Figure 3.2: Population growth and fuelwood consumption



Source: CBS (1998), MoF (1999)

people have to depend on forest fuelwood for cooking. Note also that the rural people constitute about 85% of the total population. The forest area easily reachable by local people constitutes about 51.5% of the total forest area, and is mostly located on slopes below 45° (DFRS 1999b).

The pattern of energy consumption has also changed. Between 1980 and 1998, total energy consumption increased; the percentage share of fuelwood declined after 1985 (Table 3.1). Between the same years, the use of traditional energy sources like cow dung and agricultural residues, excluding fuelwood, declined from 22 to 9%, while the consumption of commercial energy, such as coal, petroleum products and electricity, increased from 4 to 12%.

Table 3.1: Trend of energy consumption

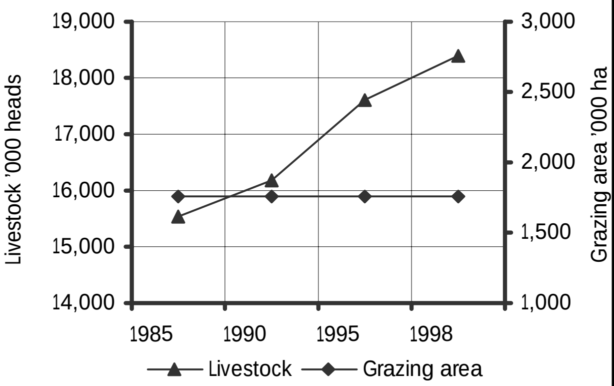
Year	Total energy used ('000 toe+)	Fuelwood as % of total energy used	Traditional energy as % of total energy used*
1980	4591	74	22
1985	5149	85	10
1990	5688	85	10
1995	6604	82	10
1998	7340	79	9

Source: WECS (1995, 1998)
* Excludes fuelwood + toe = tonnes of oil equivalent

(c) Livestock and grazing area

Much forest area is used as grazing land for livestock, the numbers of which are also increasing tremendously. This has led to further degradation of the forest area. Figure 3.3 shows that the number of livestock (cattle, pigs, goats, and sheep) increased by about 20% between 1985-1998, while the grazing area remained constant. Figure 3.4 indicates that about 10% of the livestock feed comes from the forest (Raut 1997/98).

Figure 3.3: Livestock and grazing area



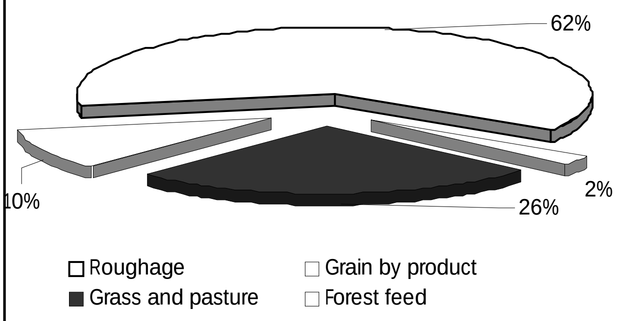
Source: MoA (1999)

The pressure on the forest varies with geographical region. From 1978-1994, the rate of estimated annual deforestation varied greatly between the Hills (2.3%) and the Terai (1.3%) (DFRS 1999a). In the former, the higher rate of deforestation might have been due to the greater dependency (42%) on fodder supply for livestock as depicted in Figure 3.5. Other reasons for forest degradation include landslides, agricultural land expansion, fuelwood demand, and infrastructural development.

(d) Human migration

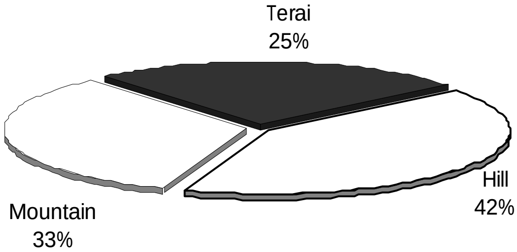
In the Terai, migration is a major factor in forest encroachment. This region has been a major destination for hill migrants for the last four decades. In 1952, the region had nearly 35% of the

Figure 3.4: Feed consumed by livestock



Source MoA (1999); Raut (1997/98)

Figure 3.5: Forest feed used by livestock by eco-region



Source MoA (1999); Raut (1997/98)

country's population, and this increased to almost 47% in 1991. During the three decades from 1961, it received over 74% of the total internal migrants (Gurung 1989). From 1978-1991, a total of 99,400 ha of Terai forests was cleared (CBS 1998), much of which was converted into cultivated area. From 1963-1979, the proportion of cropland in the Terai increased from 38.5 to 49.8% (Gurung 1989). Encroachment of forest land has occurred in the districts of Jhapa and Morang of eastern Nepal as a result of the construction of Bhutanese refugee camps in and around the forests. It is stated that, in the beginning, the refugees were provided access to forest to use the forest wood for cooking fuel and hut construction. Later, the demand for fuelwood for cooking and for cash earnings by the refugees also placed high pressure on forest resources, aggravating the situation further. The time required for local inhabitants to collect fuelwood in the refugee districts increased from an average of 1.5 hours to 8 hours (Manushi 1996; Pradhan 1998).

Forest quality in terms of crown density of forest has also degraded in the country. A study by FINNIDA (1993) on the Terai forest showed that there was a decline in the growing stock of sal (*Shorea robusta*) forest from 101 to 72 m^3/ha and for other Terai hardwood forests from 76 to 58 m^3/ha. Restocking of the forest of the upper slopes of the Middle Hills has been indicated by the Nepal Australia Community Forestry Project (Tamrakar 1996), which stems mainly from overcutting of fuelwood and lopping trees for fodder. Although no study has been carried out yet, local people say that the cutting down of trees, backed by some of the political parties, is responsible for the dwindling of forests in the country.

(e) Transboundary smuggling of logs

Another factor in degradation of the Terai forest all along the Indo-Nepal border is transboundary smuggling of logs into India. The activity intensifies when the price of the product is higher in India than in the border districts of Nepal (Rajbhandari 1997).

(f) Forest policy

Wrongly designed government forest policy is itself another factor that has contributed to reduction of forests. It is argued that the 'Private Forest Nationalisation Act 1957' appears to have been unfavourable for the protection of dwindling forest resources. The act was implemented in the country on the assumption that it could consolidate the protection and management of the forests, but conversely it rather led to degradation of the national forests by providing uncontrolled local access to them. It also completely ignored the traditional forest management practices of the people (Bajracharya 2000; Baral and Subedi 2000). Likewise, the Land Tax Act 1977 defined lands with forests as government lands. This policy also encouraged local inhabitants to cut down trees standing around their farms (Perdo 1993; Shah 1997).

3.1.3 State

(a) Distribution of forest area

The area of woody vegetation, including forest and shrub, constituted 39.6% of the country's total area in 1999 (DFRS 1999a). Approximately half is reachable (Table 3.2). The Hill forest area has

Table 3.2: Area of reachable forest by development region ('000 ha)

Region	Total forest area	Reachable forest	
		Area	% of total
FWDR	687.4	358.8	52.2
MWDR	1,192.4	454.4	38.1
WDR	734.3	262.1	35.7
CDR	918.6	527.7	57.4
EDR	736.1	576.3	78.3
Total	**4,268.8**	**2,179.3**	**51.5**

Source: DFRS (1999b)

both the largest area (381,000 ha) and the largest share of forest and shrubland. In terms of relative share of forest coverage, the Siwaliks in the Terai region have the largest density of forest cover (843,000 ha), and this area accounted for 70.4% of the total forest cover of the Terai. The forest in the Terai region is more productive and relatively more accessible than that in other areas. Thus, the Terai forests fulfill the major demands for timber and fuelwood for all towns and cities in Nepal. These forests need to be managed intensively, preferably based on local people's participation, for wood, ecosystem and genetic resource conservation, soil conservation, and watershed management (Kanel 2000).

Table 3.3 shows that the forests, in terms of criteria for both population and area, are better in the Hills than in the other two regions. Maps 3.1 and 3.2 show forest area use and community forest share in the total forest area in the country.

Table 3.3: Per capita forest distribution by physiographic zone

Physiographic regions	Area ('000 ha)	Population ('000) '91	Forest area per 100 ha	Per capita forest area
Mountain	3,507.8	1,442.3	3.37	0.08
Hill	7,203.2	8,413.4	33.80	0.29
Terai	4,007.1	8,635.3	29.86	0.14
Total/Average	14,718.1	18,491.0	29.00	0.23
Source: DFRS (1999a); CBS (1998)				

The shrub area in relation to the forest area has increased since 1978, as shown in Table 3.4. This means that forest quality has decreased. The annual reduction rate in forest area between 1978/79 and 1994 was 1.7%; the annual reduction rate in forest and shrub combined was 0.5% (DFRS 1999a). The forest area decreased in all regions from east to west, in different ratios from 1978-94 (Table 3.5). During these years, the average ratio of the decrease in forests was 24%, while shrub increased at an average of 126% (DFRS 1999a). The far-west of Nepal has the lowest forest coverage and the highest rate of loss (31%). Three other development regions lie below the average value of loss: the west, the centre, and the east (DFRS 1999a).

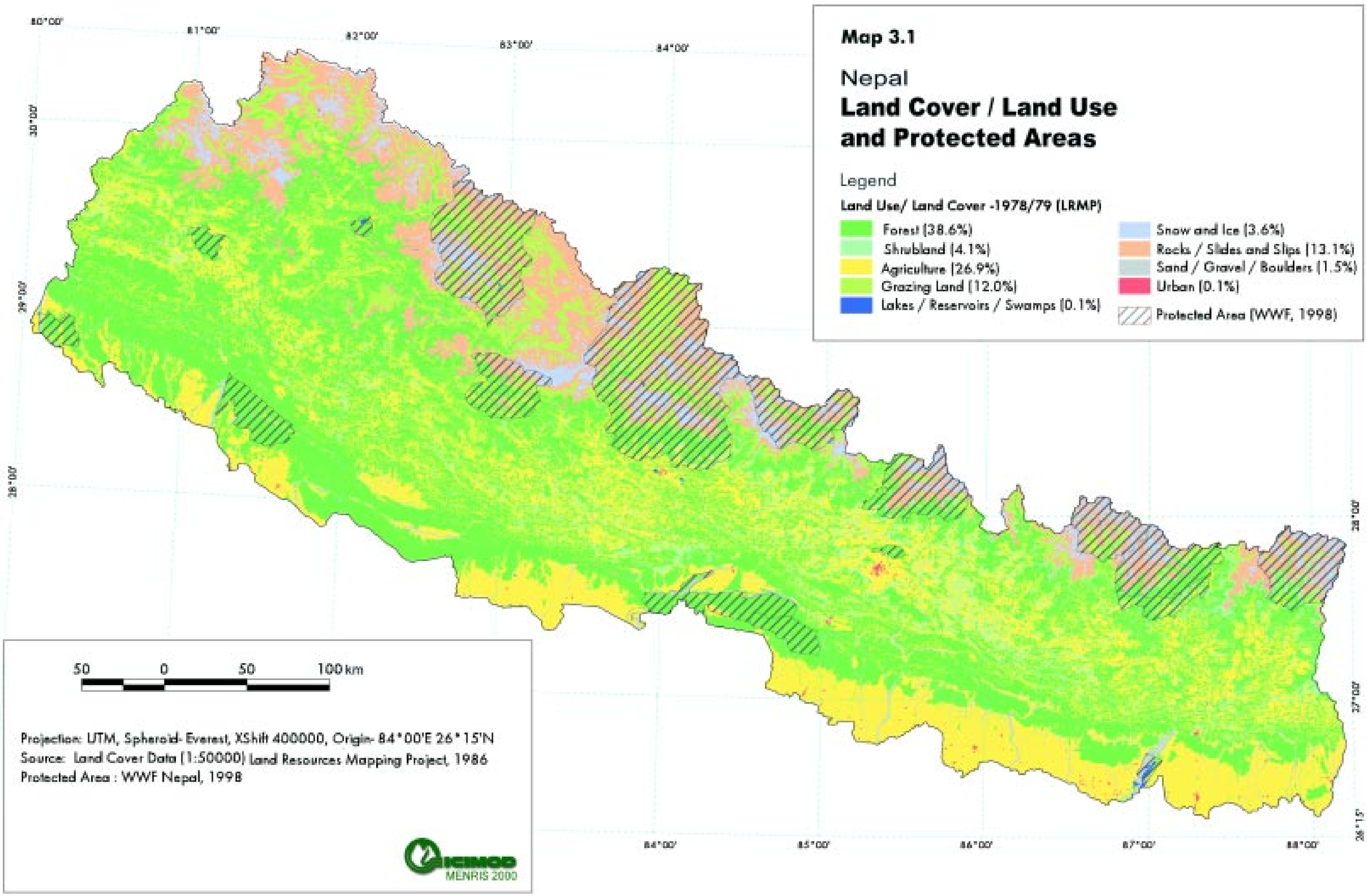
Table 3.4: Percentile change in area of woody vegetation

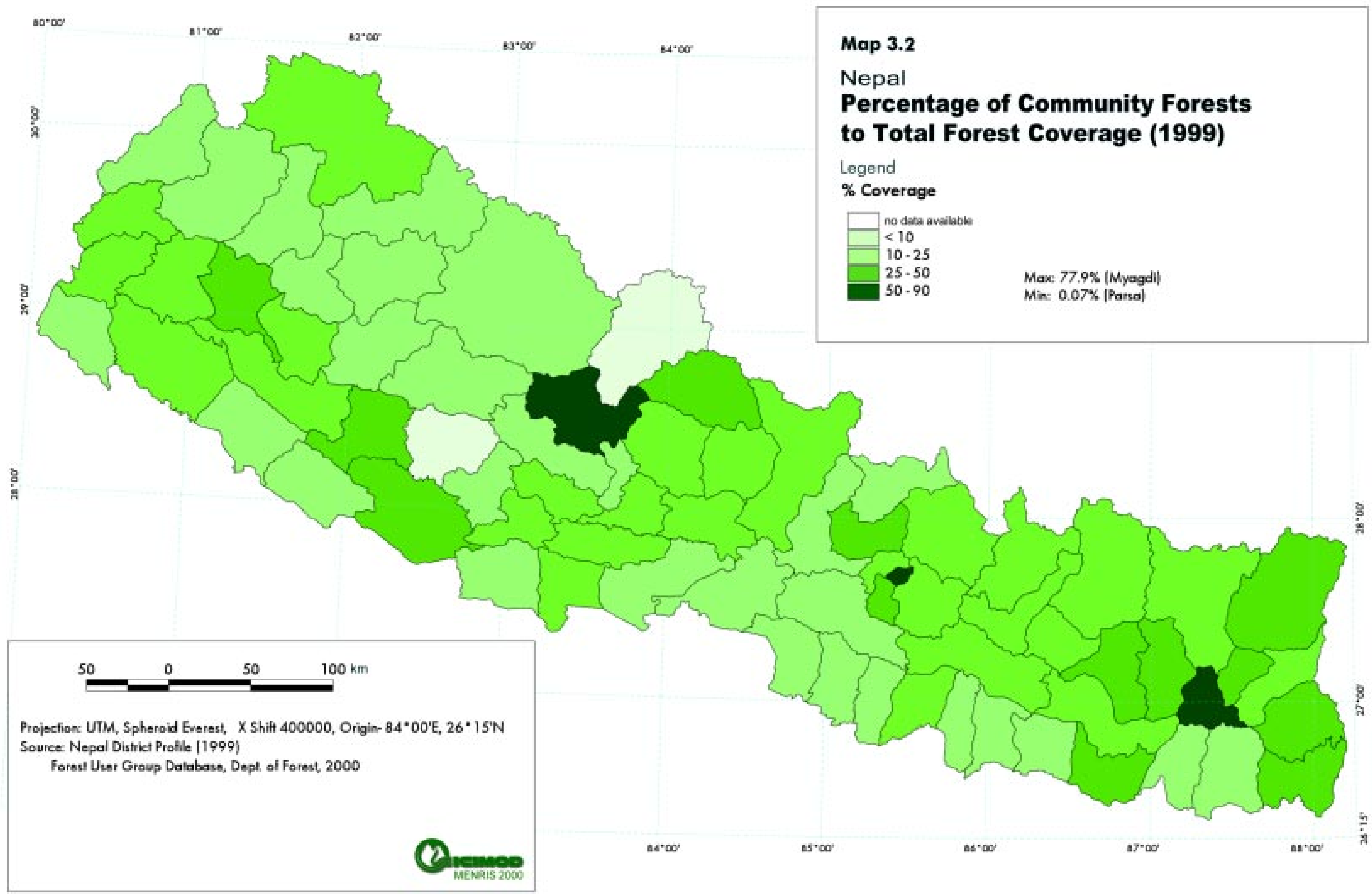
Woody Vegetation	LRMP 1978-79	Master Plan 1985-86	NFI 1994
Forest	38.0	37.4	29.0
Shrub	4.7	4.8	10.6
Total	42.7	42.2	39.6
Source: LRMP (1986); DFRS (1999a)			

The total stem volume and area of accessible forest in Nepal are about 387.5 million m^3 and 2179.3 thousand hectares respectively. The mean volume of the forest is estimated to be 178 m^3/ha. The

Table 3.5: Forest and shrub cover by development region

Region	LRMP 1978/79[1] ('000 ha)		NFI (1994)[2] ('000 ha)		Change %	
	Forest	Shrub	Forest	Shrub	Forest	Shrub
FWDR	989.5	60.4	687.4	263.9	31	337
MWDR	1,649.7	77.3	1,192.4	442.0	28	472
WDR	924.0	137.3	734.3	256.9	21	87
CDR	1,104.9	222.8	918.6	233.8	17	6
EDR	948.7	192.1	736.1	362.6	22	84
Total	5,616.8	689.9	4,268.8	1,559.2	24	126
Source: [1]MFSC (1988); [2]DFRS (1999a)						


Map 3.1
Nepal
Land Cover / Land Use and Protected Areas
Legend
Land Use/ Land Cover -1978/79 (LRMP)
Forest (38.6%)
Shrubland (4.1%)
Agriculture (26.9%)
Grazing Land (12.0%)
Lakes / Reservoirs / Swamps (0.1%)
Snow and Ice (3.6%)
Rocks / Slides and Slips (13.1%)
Sand / Gravel / Boulders (1.5%)
Urban (0.1%)
Protected Area (WWF, 1998)
80°00'
81°00'
82°00'
83°00'
84°00'
85°00'
86°00'
87°00'
88°00'
30°00'
29°00'
28°00'
27°00'
26°15'
50
0
50
100 km
Projection: UTM, Spheroid- Everest, XShift 400000, Origin- 84°00'E 26°15'N
Source: Land Cover Data (1:50000) Land Resources Mapping Project, 1986
Protected Area : WWF Nepal, 1998
ICIMOD
MENRIS 2000


Map 3.2
Nepal
Percentage of Community Forests
to Total Forest Coverage (1999)
Legend
% Coverage
no data available
< 10
10 - 25
25 - 50
50 - 90
Max: 77.9% (Myagdi)
Min: 0.07% (Parsa)
50
0
50
100 km
Projection: UTM, Spheroid Everest, X Shift 400000, Origin- 84°00'E, 26°15'N
Source: Nepal District Profile (1999)
Forest User Group Database, Dept. of Forest, 2000
MENRIS 2000

total stem volume of the forest is estimated to be 795 million m^3 and the total biomass is estimated to be 873 million tonnes (DFRS 1999b). Amongst trees with economic value, sal (*Shorea robusta*) has the highest standing volume as shown in Table 3.6.

(b) Fuelwood consumption

Table 3.7 shows that the consumption of fuelwood has increased continuously since 1980. The domestic sector consumed more fuelwood than the industrial sector. The Government of Nepal needs to promote alternative energy resources for domestic use at affordable prices if the forest resource is to be conserved. Endangered animal species depending on the forest, as shown in Table 3.8, need to be protected also.

(c) Infrastructural development

The forest has also been used for infrastructural development such as roads, schools, public places, institutional buildings, and so on. More than 120,000 hectares of forest have been used for infrastructural development (DoF 1999). Maps 3.3 and 3.4 depict the change in forest coverage in the Terai and the dry matter demand from the forest in the country, respectively.

3.1.4 Impacts

The forest in Nepal has three important functions: production of goods, protection of natural environment, and regulation of atmospheric conditions. In the Nepalese context, the production function of the forest is to be enhanced for the economic benefit of the community, while the protection and regulation functions are for ecological betterment. The ongoing trend of deforestation is having a negative impact on both the production and the protection functions of forests. Impacts of deforestation are perceived on the following fronts.

Table 3.6: Total volume of tree species of economic value

Tree species	Volume (million m^3)
Khair (*Acacia catechu*)	2.2
Satisal (*Dalbergia latifolia*)	0.4
Sal (*Shorea robusta*)	108.0
Sissoo (*Dalbergia sissoo*)	2.2
Asna (*Terminalia alata*)	37.7
Simal (*Bombax ceiba*)	2.2
Miscellaneous (*Schima wallichii, Pinus roxburghii, Pinus spp., Alnus nepalensis, Cedrus deodar etc.*)	58.8
Non-commercial	169.3

Source: DFRS (1999)

Table 3.7: Fuelwood consumption by sector

Year	Total fuelwood ('000 toe+)	% of fuelwood consumption	
		Industry	Domestic*
1980	3382	0.6	99.4
1985	4361	1.9	98.1
1990	4816	1.3	98.7
1995	5408	1.9	98.1
1998	5769	1.5	98.5

Source: WECS (1998); MOF (1999)
* Domestic sector also includes commercial consumption
\+ toe = tonnes of oil equivalent

Table 3.8: Endangered animal species

Animal Groups	World	Nepal
Amphibians	169	-
Birds	970	22
Fishes	979	-
Invertebrates	2,754	2
Mammals	741	28
Reptiles	316	9
Total	**5,929**	**60**

Source: Uprety (1997)

(a) Impact on forest structure

One major impact of deforestation is on the forest structure of Nepal. The inventory of forests shows that the growing stock of the forests has decreased in all three physiographic regions. In 1985/86, the total growing stock was 522 million m^3 over bark up to 10 cm top diameter (MPFS 1988). DFRS (1999b) estimated that the stock dwindled to 387.5 million m^3 in 1999.

(b) Impact on biodiversity

Another conspicuous impact of deforestation is on the flora and fauna. Various plant species are considered threatened as a result of deforestation and increasing pressure on their uses. A total of

60 non-endemic and 47 endemic plant species have been documented (Shrestha and Joshi 1996). The latter are found to be under immense threat. Nepal's threatened animal species, such as mammals and birds, constitute 3.8 and 2.3%, respectively, of the world's threatened species (Table 3.8).

(c) Impact on ecosystem

The occurrence of landslides, soil erosion, and floods is an every year phenomenon in Nepal (Plate 1). Deforestation may be leading to an increase in some of these natural disasters. A thin overstorey canopy of trees with virtually no regeneration, severe erosion, and low organic matter content of soil, characterise most of the degraded forest. Over the sloping areas of the middle hills, the farmers have cleared forests for cultivation to meet their food requirements. This has resulted in environmental degradation in the form of accelerated soil erosion leading to land degradation, declining productivity, and sedimentation in downstream areas (Zimsky 1999).

Plate 1: Landslide on a steep slope affecting human settlements *(ICIMOD)*

Table 3.9: Effects of floods and landslides

Year	Death of persons	Total financial loss* (US$ 000)	Degraded land area (ha)
1984	363	2,050	1,240
1988	328	341,223	-
1989	680	90,760	-
1990	307	1,502	1,130
1991	93	494	280
1992	71	252	140
1993	1,336	99,110	5,580
1994	49	1,192	390
1995	-	-	41,870
1996	258	208,787	7,793
1997	78	1,649	-
1998	273	28,854	-

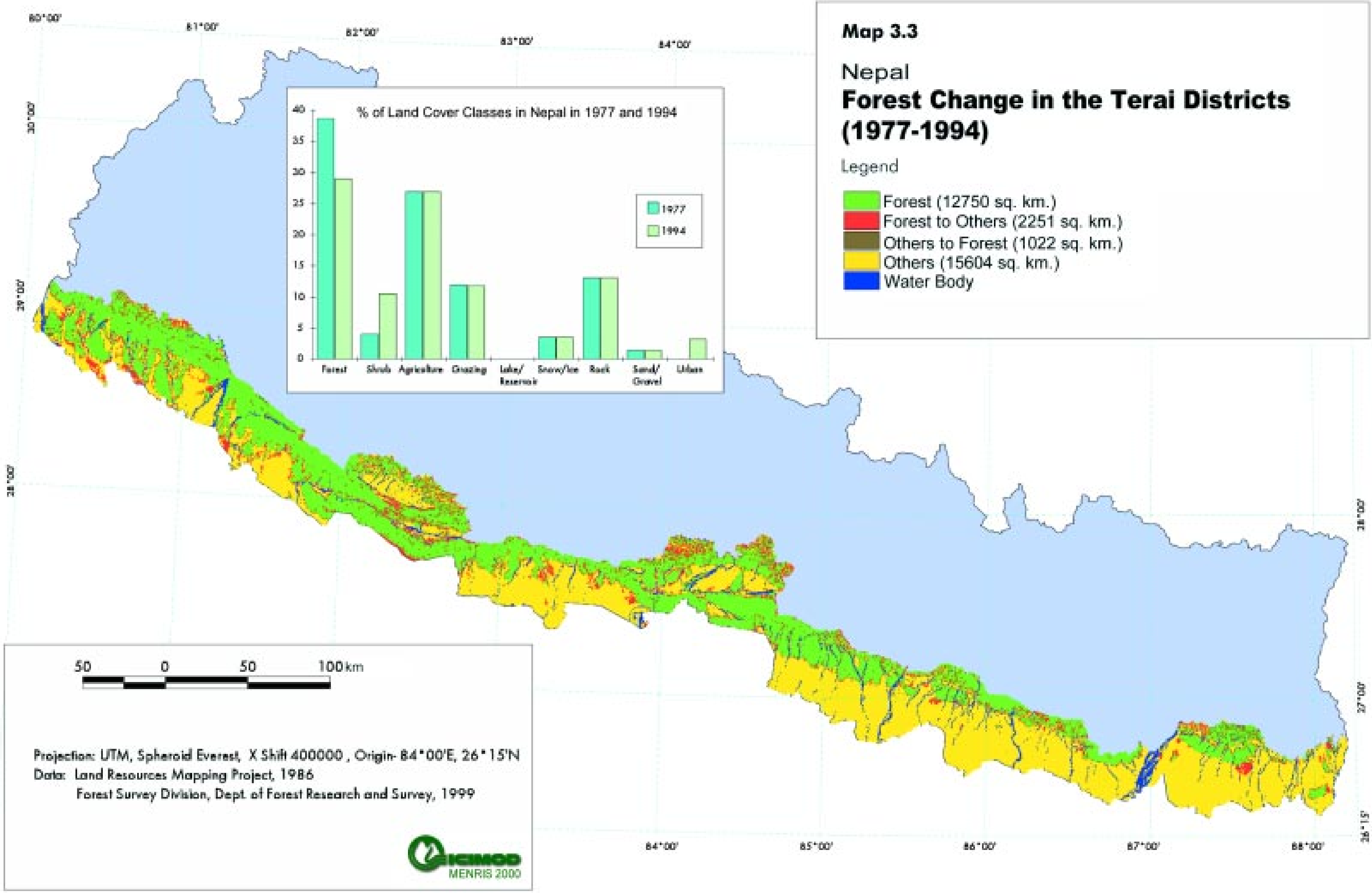
Source: MOHA (1999); DPTC (1997)
* Includes loss of livestock, agricultural land, houses, roads, etc

The occurrence of floods and landslides as a result of deforestation has affected not only the degradation of land but also human lives and property. Table 3.9 depicts the consequences of floods and landslides in the country. The degree to which lives and property are lost and land degraded has been found to vary in different years.

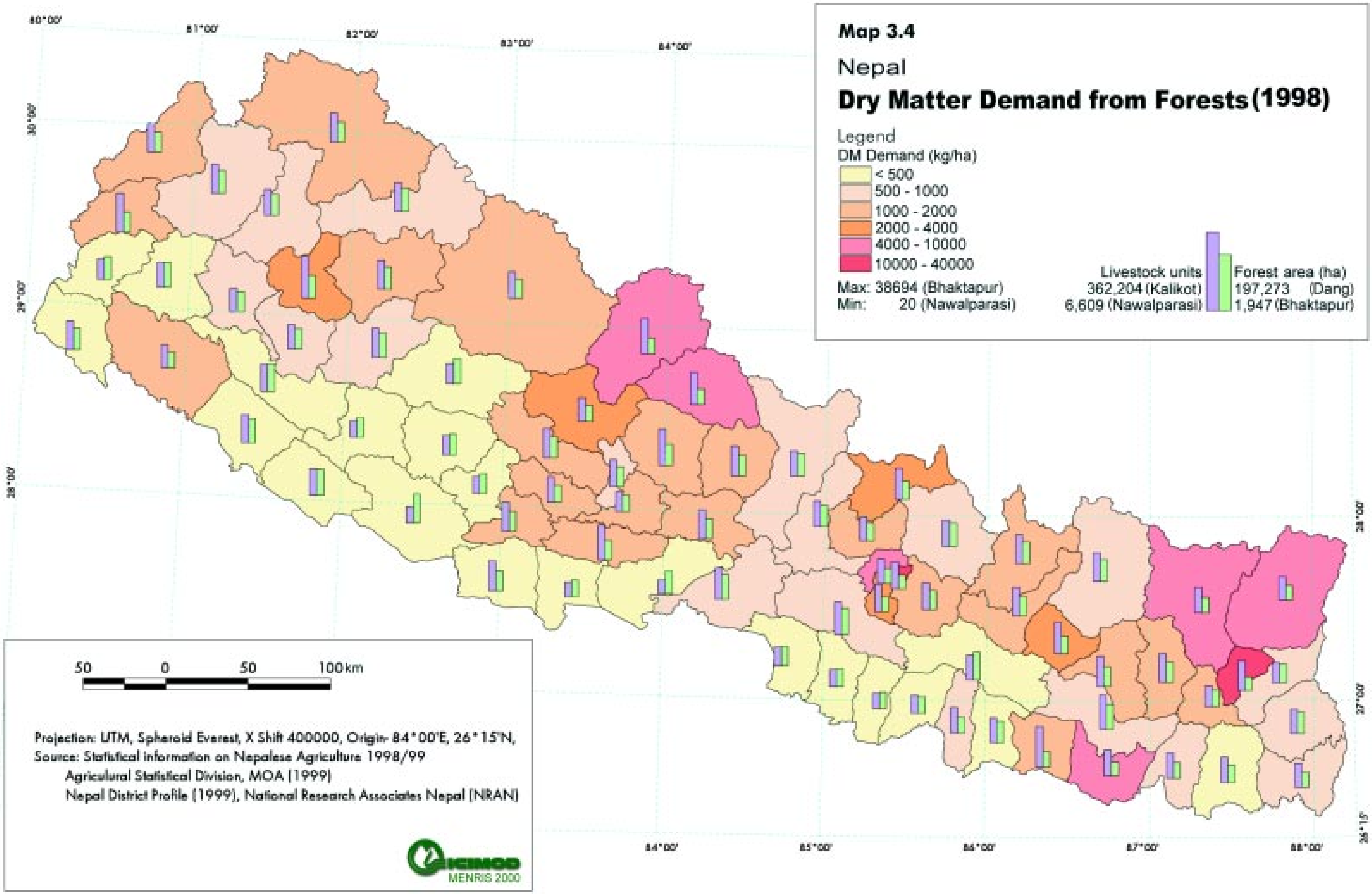
(d) Impact on the atmosphere

The burning of forest fuelwood has changed the local atmosphere, particularly in rural areas of the country where fuelwood is the main source of heat energy (Plates 2 and 3). Due to burning fuelwood and deforestation, the concentration of carbon dioxide (CO_2) in the atmosphere has increased (Figure 3.6). The increase in CO_2 in the atmosphere has added to the greenhouse effect and, as a result, the amount of radiant energy has also increased, thereby warming the local climate.

It is estimated that annual deforestation of 26,602 ha has emitted 7.77 million tonnes of carbon into the atmosphere (SEAMCAP 2000). The burning of fuelwood has also emitted considerable amounts of other pollutants such as TSP, HC, NO_2, and SO_2 into the atmosphere as shown in Table 3.10.



Map 3.3
Nepal
Forest Change in the Terai Districts (1977-1994)
Legend
Forest (12750 sq. km.)
Forest to Others (2251 sq. km.)
Others to Forest (1022 sq. km.)
Others (15604 sq. km.)
Water Body
% of Land Cover Classes in Nepal in 1977 and 1994
1977
1994
Forest
Shrub
Agriculture
Grazing
Lake/ Reservoir
Snow/Ice
Rock
Sand/ Gravel
Urban
50 0 50 100 km
Projection: UTM, Spheroid Everest, X Shift 400000, Origin- 84°00'E, 26°15'N
Data: Land Resources Mapping Project, 1986
Forest Survey Division, Dept. of Forest Research and Survey, 1999
MENRIS 2000


Map 3.4
Nepal
Dry Matter Demand from Forests (1998)
Legend
DM Demand (kg/ha)
< 500
500 - 1000
1000 - 2000
2000 - 4000
4000 - 10000
10000 - 40000
Max: 38694 (Bhaktapur)
Min: 20 (Nawalparasi)
Livestock units
362,204 (Kalikot)
6,609 (Nawalparasi)
Forest area (ha)
197,273 (Dang)
1,947 (Bhaktapur)
50 0 50 100 km
Projection: UTM, Spheroid Everest, X Shift 400000, Origin- 84°00'E, 26°15'N,
Source: Statistical information on Nepalese Agriculture 1998/99
Agricultural Statistical Division, MOA (1999)
Nepal District Profile (1999), National Research Associates Nepal (NRAN)
ICIMOD
MENRIS 2000

(e) Impact on forest access

As a result of deforestation, the distance traveled by rural people to reach the forests has increased considerably. In 1985/86, the total accessible forestland in the country was 5.8 million ha. In 1992/93, it declined to 4.6 million ha (CBS 1998). This means that rural people had to travel increasing distances to collect forest products, thereby reducing the time available for other productive activities (Zimsky 1999).

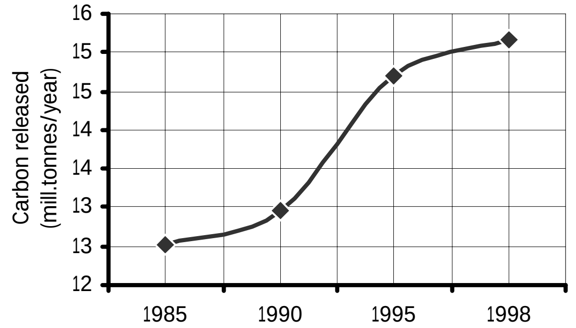
Plate 2: Cutting down trees near a settlement, en route to Langtang National Park *(G. Joshi)*

Plate 3: Fuelwood from the forest of Langtang National Park – what alternative source is there? *(G. Joshi)*

(f) Export of forest products

Export of forest products, including timber and non-timber varieties, to India declined sharply from 1975 to 1985. Total exports, including to India, have remained more or less stable since 1990 (Figure 3.7). Export of timber and non-timber products is shown in Figure 3.8. According to the statistics of MoF (1999), in 1975 timber export reached a maximum value of about US$ 28 million and then declined sharply to a minimum of US$ 0.1 million in 1981. Compared to timber, non-timber exports remained more or less constant. In 1980, the value of non-timber exports was US$ 5.6 million and this declined to US$ 2.7 million in 1998. Note that timber export was banned in 1984.

Figure 3.6: Carbon released by deforestation and fuel burning



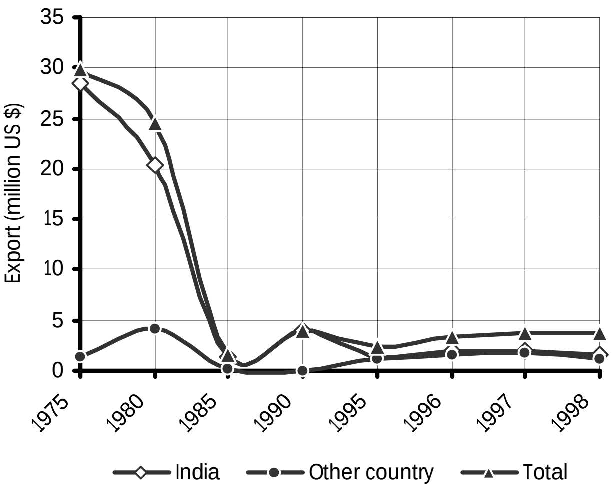
Source: WECS (1998); DFRS (1999a)

Table 3.10: Total emission (tonnes/year) from fuelwood use

Year	TSP	CO	HC	NOx	SOx
1980	138,749	346,872	309,583	10,406	5,203
1985	178,913	447,282	399,199	13,418	6,709
1990	197,579	493,949	440,849	14,818	7,409
1995	221,867	554,667	495,040	16,640	8,320
1998	236,677	591,692	528,085	17,751	8,875

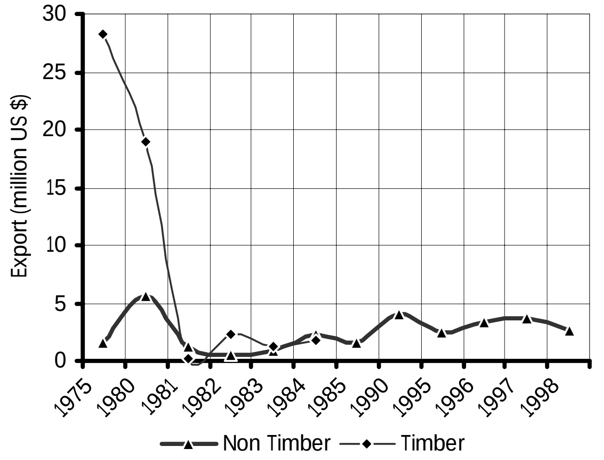
Source: MOF (1999)

Figure 3.7: Export of forest products, Nepal



Source: MoF (1999)

Figure 3.8: Export of major forest commodities



Source: MoF (1999)

3.1.5 Responses

Until 1951, the policies for forest development in Nepal adopted by the Rana rulers identified forests located in strategic places for protection and maintenance as security zones for defence (Plate 4). Forest resources were used as one of the main sources of government revenue. But the land tax policy for agricultural development converted many forests into agricultural lands in the Terai during this time. After 1951, the government undertook the following activities with regard to forest resource development.

Plate 4: Protected forest in Langtang National Park still lacking proper management *(G. Joshi)*

(a) Forestry sector legislation

Nepal began to enact acts and legislation related to the forestry sector in 1957. The main policies and legislation are as follow.

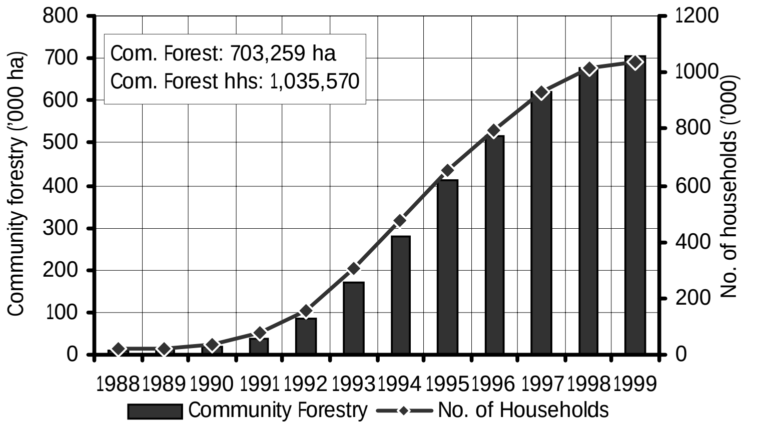
- The National Forestry Plan (1976)
- National Conservation Strategy (1988)
- The Master Plan for the Forestry Sector (1989 – 2010)
- Forestry Sector Policy (1989)
- Nepal Environmental Policy and Action Plan (1993)
- Policy Document: Environmental Assessment in the Road Sector of Nepal (2000)
- Private Forest Nationalisation Act (1957)
- Forest Act (1961)
- Forest Protection Act (1967)
- The National Parks and Wildlife Conservation Act (1973) and its amendment (1993)
- The Soil Conservation and Watershed Act (1982)
- The Forestry Act (1992) and amendment (1998)

- Forest Regulation Act (1995)
- The EIA guidelines for the Forestry Sector (1995)
- Environmental Protection Act (1996)
- Buffer Zone Regulation (1996)
- The Plant Protection Act (1997)
- The Environmental Protection Regulation (1997)

(b) Government programmes

Some of the government programmes on forest resource development are as follow.

Figure 3.9: Households and community forestry



Source: DoF (1999)

- One of the main government efforts is the community forestry programme, initiated in 1978, emphasises sustainable management and development of forests through involving communities as forest user groups. The programme has been very important with regard to forest development. By 1999, the government had handed over a total of about 0.7 million ha of state-owned forests to over 10,532 community forestry user groups for development, conservation, management, and sustainable use (Figure 3.9). A total of six million people directly benefited from being members of the user groups by 2000 (Plate 5).
- The next striking feature of forest resource developments recently undertaken is leasehold forest management through user groups. In 1993, a total of 270 hectares of state-managed forest was handed over to user groups for leasehold forestry and this increased to over 6,550 hectares in 2000.

Plate 5: Community forestry programme: an encouragement for nature conservation *(ICIMOD)*

- Another feature of forest conservation is management of forest areas as protected areas such as national parks, wildlife reserves, and conservation areas. The coverage of protected areas increased from 0.976 million hectares in 1984 to 2.476 million hectares in 1998.
- The government has adopted appropriate technology for alternative energy to help reduce dependency on traditional energy sources such as fuelwood. The Alternative Energy Promotion Centre (AEPC) has prepared a 20-year Master Plan on alternative energy.

During the Eighth Plan period (1991-96), a total of 32,119 biogas plants was installed and generated 75 megawatts of energy (Table 3.11). As this was small compared to the total potential of 2,400 megawatts, the Ninth Plan (1997-2002) has a scheme to install 90,000 biogas plants. In addition, the plan will launch an Improved Cooking Stove (ICS) programme in 45 districts, aimed at installing about 150,000 stoves. The non-government sector will also install an additional 100,000 improved stoves.

Table 3.11: Potential versus installed biogas units, households by physiographic region

Potential & Installed Biogas	HH by physiographic region			Total HH
	Mtn.	Hill	Terai	
Potential Biogas	11,636	593,831	891,925	1,497,392
Installed Biogas	318	16,028	15,773	32,119

Source: CBS (1998)
HH = Households

The Ninth Plan has a scheme to install solar energy photovoltaic systems in 38,000 households in remote areas that cannot be linked with the central grid system and where micro-hydro electricity is not feasible. About 300 solar dryers will be installed during the Plan period in order to help provide energy and increase the income of rural communities.

(c) Nepal's signature on international conventions and treaties

Nepal has signed various international conventions and treaties related to the conservation of forests and biodiversity, as shown in Table 3.12.

Table 3.12: International conventions and treaties related to the conservation of forests and biodiversity

Conventions	Date	Nepal's Signature	Main objective	Major obligation
Plant Protection Agreement for South East Asia and the Pacific Region	27 Feb 1956	12 Aug 1965	Prevent introduction and spread of destructive plant diseases and pests	Regulate trade of plants, and plant products
Convention on the International Trade in Endangered Species of Wild Fauna and Flora (CITES)	3 Mar 1973	18 Aug 1975	Protect and regulate the trade in wild fauna and flora and their products	Protect all species threatened legally and regulate trade
Convention on Wetlands of International Importance especially Waterfowl Habitat (Ramsar Convention)	2 Feb 1971	17 Dec 1987	Prevent the loss of wetlands	Conservation and sustainable use of migratory stocks of wildfowl
International Tropical Timber Agreement (ITTA)	18 Nov 1983	3 Jul 1990	Ensure conservation and sustainable use of timber and enhance international timber trade	Implement activities for forest management and decisions on timber trade
Agreement on the Network of Aquaculture Centres in Asia and the Pacific	8 Jan 1988	4 Jan 1990	Aquaculture development for increasing rural income	Expand network of aquaculture centres
Convention on Biological Diversity	5 Jun 1992	15 Jun 1992	Ensure conservation and sustainable use of biological resources	Prepare and implement national strategies for the conservation of biodiversity
UN Convention to Combat Desertification	17 Jun 1994	12 Oct 1995	Combat desertification	Prepare national action Plan and implement programmes for poverty alleviation

3.1.6 Conclusion

In order for the forestry sector to achieve significant growth and continue to contribute to Nepal's national economy, forest resources need to be used and managed in an integrated as well as an intensive manner. There is also a need to ensure that ecological constraints are addressed regularly and in a sustainable way. The main objective of forest resource management should be to develop and implement an integrated programme of resource management, including watershed management and biodiversity conservation.

There is a need to generate large-scale employment in the forestry sector through involving people in forest management, protection, plantation, harvesting and transportation, and wood-processing industries. Concomitantly, supplementary incomes can be generated for rural farm families through community, leasehold, and private forestry. In this context, it should be realised that generation of income and employment are more important than government revenue alone and government agencies, NGOs, and private firms should work constructively for the benefit of society. The new and more responsible roles of the Nepalese forestry sector will guide it in new directions during the twenty-first century.

This objective calls for pragmatic and practical policies and legislations in forest development. There is no doubt that the existing policies and legislation are not adequate. Some of the issues that have been observed and discussed here should be addressed. The changes needed in policy issues are stated below under recommendations.

(a) Gaps

Some of the data gaps identified in the forestry sector include the following.

- The total forest area that has been encroached upon by different sectors.
- Considerable numbers of trees are outside the public forest. Villagers use many of them for fodder, fuelwood, and timber. Their existence, therefore diminishes pressure on the forest. However, there is a data gap on the area covered by such trees.
- There is no detailed information on endangered plant species. Surveys should be conducted to collect information on such plant species.

(b) Recommendations

- All the forests of the Siwalik Hills need to be declared protected forests for conservation of the ecosystem.
- Extensive plantation of trees should be undertaken wherever there are vacant public lands such as village wastelands, in and around farms, rural and urban parks, temple and school premises, and along roads and rivers. NGOs should be involved extensively in such activities. For this, the relevant government agencies should be activated.
- Plant resources should be surveyed and catalogued so that the conservation of endangered and vulnerable plant species can be carried out.
- The private sector should be encouraged to participate in the use and management of forests as far as possible.
- The provision of a leasehold forestry programme for groups of people living below the poverty line needs to be reassessed so that no conflict between the programme and the User Group Community Forestry Programme exists.
- Public awareness about the importance of forests and the consequences of deforestation is very important. Public awareness about forest conservation needs to be raised through public media, posters, drama, school education programmes, and so on. The local elite, political leaders, social activists, and NGOs should be involved in public awareness programmes about forest conservation.

- Forest research should focus on basic issues of forest conservation at local level so that more realistic measures and policy programmes can be devised.

3.1.7 Proposed Projects

A cost analysis of some proposed projects related to forest conservation is given below.

Project 1: Data Gaps in Private Forestry

Executive and promoting organisation:	Ministry of Forests
Implementing organisation:	Local NGOs or other private agencies working in related fields.
Duration:	1 year
Location:	District Offices
Cost:	The total estimated cost is US$ 26,000
Rationale:	Public or community forestry alone cannot meet the growing demand for forest products. Private forestry can play a vital role in changing the life of the people by supplying raw materials to industry and fuelwood for domestic consumption. However, no studies have been made to date to provide information about the state of private forestry. Thus, the purpose of this study is to fill the data gap. The study will provide information about the status of private forests, present policy, and its obstacles, as well as future development potential for poverty alleviation and development of the country.
Methodology:	The study will be carried out in four phases. The duration of the study will be around 6 to 8 months.

Project 2: Use of Improved Stoves

Executive and promoting organisation:	Ministry of Science and Technology
Implementing organisation:	Local NGO working in a related field
Duration:	2 years
Location:	Both rural and urban areas in each district where fuelwood is used domestically.
Cost:	The estimated cost for the districts of all five-development regions is US$ 50,000 per year.
Rationale:	About 90% of the fuelwood is used in the domestic sector for cooking. This releases about 93% of the total suspended particulate matter. This could be one of the causes of respiratory disease, which is one of the ten leading diseases of Nepal. The improved stove would save about 25-35% of fuelwood. If the improved stove were used throughout the country, the pressure on fuelwood would be minimised. On average, about 35-40% of the total round wood cut from the forest is used as fuelwood.
Methodology	Each region will have a regional station for the necessary management and supervision of improved stove activities. Each of the communities interested will receive one set of information, education, and communication (IEC) materials from the regional office. Monitoring of distribution of IEC material as well as motivation will be carried out regularly. No subsidies will be provided for the programme.

References

Bajracharya, K.M. (2000) *Intensive Management of the Terai and Inner Terai Forests in Nepal*. Report submitted to Nepal Forest Association, Kathmandu

Baral, I.C.; Subedi, B.R. (2000) *Community Forestry: Government Forestry Controversy in the Terai: Some Thoughts for Reconciliation*. Kathmandu: publisher not given

CBS (1998) *A Compendium on Environment Statistics 1998*. Kathmandu: CBS

DoF (1999) *Records on Community Forest*. Kathmandu: DoF, Community and Private Forestry Division

DPTC (1997) *Annual Disaster Review – 1996*. Kathmandu: DPTC, Water Induced Disaster Prevention Centre

EPC (1993) *Nepal Environment Policy and Action Plan*. Kathmandu: EPC

FINNIDA (1993) *Changes in the Terai Forests of Nepal (1964 - 1990)*. Kathmandu: DFRS

DFRS (1999a) *Forest and Shrub Cover of Nepal 1994 (1989-96)*. Kathmandu: HMGN/DFRS, Forest Survey Division

DFRS (1999b) *Forest Resources of Nepal (1987-1998)*. Kathmandu: HMGN, DFRS

DoHS (1999) *Annual Report*. Department of Health Services (1997/1998). Kathmandu: DoHS

Gurung, H. (1989) *Regional Patterns of Migration in Nepal*. Papers of the East-West Population Institute, No.113. Hawaii: E-W Institute

HMG (1997) *The Community and Private Forestry Program in Nepal*. Internal Report, DoF, Community and Private Forestry Division

Kanel, K.R. (2000) *Concept Paper to Manage the Forests of the Terai and the Churia Hills* (Nepali text, Second Draft). Report submitted to Nepal Forest Association, Kathmandu

LRMP (1986) *Land System Report*. Kathmandu: HMGN/LRMP

Manushi (1996) *Socio-Economic and Environmental Impact of the Presence of Bhutanese Refugees on the Local Community in Eastern Nepal*. Kathmandu: UNCHR

MFSC (1988) *Main Report: Master Plan for the Forestry Sector*. Kathmandu: HMGN, MFSC

MFSC (1996) *Forestry Sector Policy (Draft)*. Kathmandu: HMGN, MFSC

MoA (1999) *Statistical Information on Nepalese Agriculture, 1998/99*. Kathmandu: HMGN/MoA, Agricultural Statistics Division

MoHA (1999) *Loss of Lives due to Flood and Landslides* (unpublished). In the Records of the MoHA, Kathmandu

MoF (1999) *Economic Survey* (FY 1998/99). Kathmandu: HMGN/MoF

MoPE (1997) *Combating Desertification*. Kathmandu: HMGN/MoPE

MoPE (1997) *The Environment Protection Act 1996 and the Environment Protection Regulation 1977***.** Kathmandu: HMGN/MoPE

MPFS (1988) 'Master Plan for Forestry Sector Nepal'. In *Soil Conservation and Watershed Management Plan*. Kathmandu: HMGN/MFSC

NDP (1999) 'Nepal District Profile'. In Sharma, H.B.; Gautam, R.P. (eds) *National Research Associates Nepal* (NRAN). Kathmandu: NRA

NPC (1974) *Draft Report on Land Use and Erosion Control. Report of the Task Force*. Kathmandu: NPC

NPC/HMGN (1997) *The Survey of the Government's Ninth Plan (1997 - 2002)*. Kathmandu: NPC

Perdo, R.D. (1993) 'Back to the Future: Nepal's New Forestry Legislation.' In *Journal of Forestry*, June

Pradhan, H.B. (2000) *A Study on the Change in Forest Resources of the Koshi Hills in the Eastern Hill Districts*. Kathmandu: Nepal-UK Community Forestry Project

Pradhan, P. (1998) *Development of a GIS Database System for Refugee Programs in Eastern Nepal: Status of Environmental Conditions and Impacts Assessment*. Bangkok: UNEP/GRID

Rajbhandari, M.D. (1997) *A Draft Programme Document on Forest Resource Information System*. Report submitted to FINNIDA, Kathmandu

Raut, Y. (1997/98) *A Handbook of Animal Husbandry* (Part I: Pasture Production). Kathmandu: MoA, Department of Livestock Services

SEAMCAP (2000) *State of Environment Dataset Report: Strengthening Environment Assessment and Monitoring Capabilities in Nepal* (unpublished report). Kathmandu: UNEP EAP.AP/MoPE/ICIMOD

Shah, S.B. (1997) *Analysis of Forestry Sector Policy and Legislation.* Draft Report submitted to DoF, Kathmandu

Shrestha, T.B.; Joshi, R.M. (1996) *Rare, Endemic and Endangered Plants of Nepal*. Kathmandu: WWF - Nepal Programme

Tamrakar, R.M. (1996) *A Comparative Study of Land Use Changes in the Upper Catchment Area of Sindhupalchok District between 1978 – 1992*. Unpublished Consultancy Report to the Nepal Australia Community Forestry Project, Kathmandu

Uprety, B.K. (1997) *Natural Biodiversity: Institutional Strengthening and Collection of Environmental Statistics in Selected DMCs*. Kathmandu: CBS

WECS (1996) *Energy Synopsis Report, Nepal 1994/95*. Kathmandu: MoWR, WECS

WECS (1995) *The Energy Resource Base of Nepal*. WECS Report, No. 2/1/010595/5/11, No. 480. Kathmandu: WECS

WECS (1998) *WECS Bulletin*, 9(1)

WECS (1999) *WECS Bulletin, 10 (1 and 2)*

Zimsky, M. (1999) *National Biodiversity Action Plan (*Draft). Kathmandu: HMG, MFSC

3.2
SOIL DEGRADATION

3.2.1 Introduction

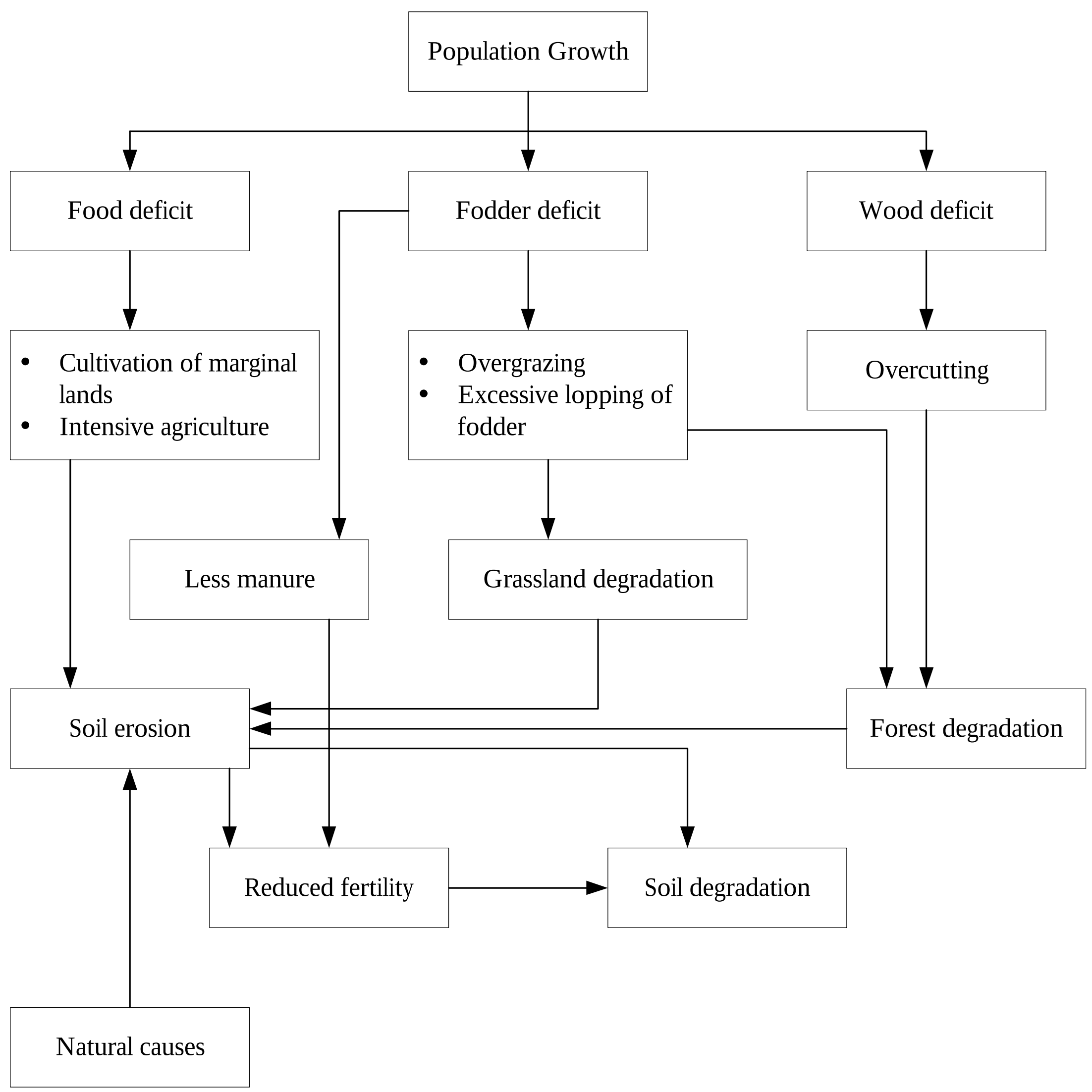
Soil is a mixture of mineral and organic components. Its degradation refers to diminishment of the present potential capability of fertility. Soil degradation is of two basic types: soil erosion and in situ soil deterioration. Soil erosion refers to the physical wearing down of the earth's surface and includes surface erosion and mass wasting. While surface erosion is the loss of top materials due to the action of water or wind, mass wasting involves the movement of large masses of fractured rock or other unconsolidated materials, including soil, from a mountain slope. Soil erosion can either be natural or man-induced. In situ soil deterioration includes acidification, loss of nutrients, salinisation, and others.

The magnitude of soil degradation in a place depends on the local geology, soil type, landform, land use, rainfall intensity, and human activity. The flow diagram shown in Figure 3.10 summarises the causes of soil degradation in Nepal.

3.2.2 Pressure

Soil degradation is recognised as a serious environmental problem in Nepal. The country is mountainous for the most part (> 80%) and the terrain is rugged and characterised by unstable and steep slopes, making it vulnerable to exogenous factors. Of these, the torrential monsoon rainfall that

Figure 3.10: Causes of soil degradation and their relationships, Nepal

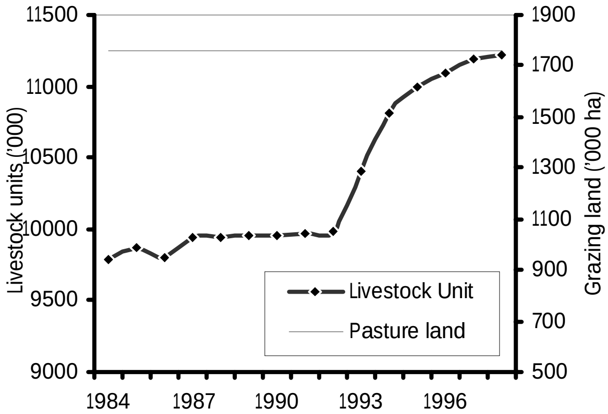


occurs within a short span of time is an important cause of soil erosion from mountain slopes. On the other hand, different forms of mass wasting, such as landslides, slumps, rockfalls, and river cuttings are responsible for sedimentation in the valleys, plains, and river basins, which also causes degradation of soil fertility.

- The rapid growth in population is putting severe pressure on natural resources such as soil. In 1999, the estimated population was 22.4 million (MoPE 1998). Because of lack of employment opportunities, many derive their livelihood solely from the primary production of foods, fodder, and wood, and keeping animals. Production is being intensified, causing deforestation, pasture depletion, and encroachment of steep slopes.
- In 1977, the forest area was 56,168 sq.km, which declined to 42,690 sq.km in 1994, an annual decrease of 1.7% (DFRS 1999a).
- Likewise, in 1998 the livestock population of buffalo, cattle, goats, and sheep reached 17.6 million head, equivalent to 11,226 thousand livestock units, increased from 14.9 million head, equivalent to 9,790 thousand livestock units, in 1984 (Figure 3.11). The livestock units have increased abruptly since 1992; this is mainly due to the increase in the number of cattle. The increasing livestock population has no other way but to count on already depleted forest, and on a pasture area that has remained more or less constant over the last 15 years, causing massive soil erosion at greater rates (Table 3.13).
- The agricultural land is already subject to ever greater intensification of use through double and multiple croppings to produce more food for an ever-increasing population. Inadequate and imbalanced application of fertilisers has further accentuated the decline in soil fertility.
- Development work, particularly the construction of roads and irrigation canals, has also contributed to landslides and soil erosion. Laban (1979) estimated that five per cent of all landslides in Nepal are associated with roads and trails. The total length of road rose to 13,223 km in 1998 from 4,949 km in 1980 (DoR 1999). It is observed that, after roads are built, they are usually ravaged by recurrent landslides and rockfalls during the monsoon season.
- Although information is not available, stone quarrying is probably one of the factors causing soil erosion.

Figure 3.12 indicates that there is intense pressure on agricultural land. The population

Figure 3.11: Trend of livestock units and pasture land



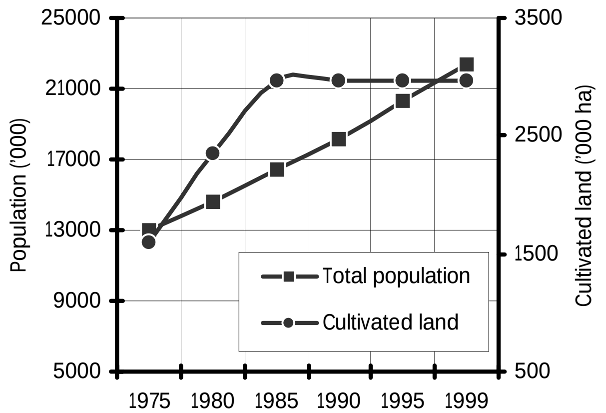
Source: DoA (1999); Raut (1997/98)

Table 3.13: Livestock pressure on grazing land resources

Ecological region	Pasture Area (ha)	Pasture %	Livestock units (LU)	Stocking rate (LU/ha)
Mountain	1,382,232	78.7	1,286,585	1
Hill	302,204	17.2	5,812,277	20
Terai	72,564	4.1	4,127,053	58
Total	**1,757,000**	**100**	**11,225,915**	**6.5**

Source: MOA (1999)

Figure 3.12: Change in population and area of cultivated land



Source: CBS (1999); MoA (1999)

has constantly increased, but the officially reported area of agricultural land has remained constant since 1985 (DoA 1999). The fact that the reported area of agricultural land has not changed since 1985 might indicate that the amount of new land taken for agricultural purposes is the same as the amount lost to non-agricultural uses. Local experience indicates that former forest areas and marginal lands, including unsuitable and environmentally sensitive steep slopes, are still being brought under cultivation because the amount of other suitable, agricultural land is insufficient.

- The constant increase in the population depending on agriculture has many implications. One consequence is that the process of fragmentation of agricultural land parcels has continued because of an increase in the number of farming households, turning landholding parcels into uneconomic sizes in terms of modern agricultural practices. Secondly, there is a skewed distribution of landholdings among farmers, and this has hindered agricultural land development (Table 3.14). The number of marginalised and small farmers with landholdings below one hectare accounts for 69.4% but these farms cover only 30.5% of the total landholding area. Shifting cultivation has persistently existed in scattered form in the remote hills, encroaching upon forests. The impacts of land degradation such as landslides, soil erosion, and flash floods, are the most pressing problems in Nepal. These are every year phenomena that take place particularly during the rainy season. While landslides and soil erosion occur over the hills and mountains, flash floods occur in the valleys and the Terai plains. The increase in the former is partly the result of uncontrolled expansion of farming on to unsuitable marginal lands due to an increase in population and shifting cultivation practices, whereas the latter is due to deposition of debris on riverbeds during flooding. These have caused not only a decline in productivity of agricultural land but have also affected the lives of the people. Deaths caused by landslides and floods numbered 363 in 1984 and rose to 1,336 in 1993, a record year. The financial loss in 1993 amounted to US$ 99.1 million, and US$ 1.9 million in 1984 (DPTC 1997).

Table 3.14: Number and area of landholdings by size, 1992

Size of holding (ha)	Holdings			Area of holdings		
	Number ('000)	%	Cum %	Area ('000ha)	%	Cum %
> 0.1	173.0	6.4	6.4	9.6	0.4	0.4
0.1 - 0.2	263.8	9.8	16.2	38.0	1.5	1.9
0.2- 0.5	729.3	26.9	43.1	244.8	9.4	11.3
0.5- 1.0	711.7	26.3	69.4	499.5	19.2	30.5
1.0 - 2.0	529.5	19.6	89.0	716.5	27.6	58.1
2.0 - 3.0	168.4	6.2	95.3	400.2	15.4	73.5
3.0 - 4.0	59.6	2.2	97.5	202.4	7.8	81.3
4.0 - 5.0	28.6	1.1	98.5	125.7	4.8	86.1
5.0 - 10.0	32.0	1.2	99.7	209.3	8.1	94.2
> 10.0	8.2	0.3	100.0	151.3	5.8	100.0
Total	**2704.1**	**100**		**2597.3**	**100**	

Source: CBS (1999)
Cum = Cumulative

- Another feature of land degradation is desertification; this is seen in Dolpa and Mustang in west Nepal, affecting about 10,000 hectares of dry and cold land. It results from the fact that scanty vegetation on marginal land is grazed by an excessive number of livestock.
- The land system, particularly in and around major urban areas, is affected by solid waste disposal. Production of municipal waste increased from 0.144 million tonnes in 1984 to 0.330 million tonnes in 1997 (CBS 1998). Likewise, production of toxic and hazardous waste increased from 270 to 512 tonnes in the same time interval (Tuladhar 1999). This waste is disposed of on land surrounding towns or in water bodies without any treatment.
- More land is being taken for agriculture, but, at the same time, the most fertile lands are being turned into non-agricultural uses such as urban areas, industries, road construction, and biodiversity conservation or buffer zone conservation (in Chitwan National Park). Major cities have expanded, encroaching upon prime agricultural land.

3.2.3 State

(a) Soil erosion

Owing to the complex features of the mountain terrain, the nature of soil degradation varies greatly. However, information on soil degradation is scattered and sketchy. Table 3.15 provides information on the soil erosion rates for different land-use categories (MPFS 1988). The soil erosion rate appears to be higher in the unmanaged land-use category and on steep slopes than in the managed land-use category (Plate 6). A study in the Jhikhu Khola watershed in the middle hill district of Kabhre found that the rate of soil loss from open degraded areas reached 25-40 tonnes/ha/year compared to 3-25 tonnes/ha/year from cultivated outward sloping terraces (ICIMOD 1998).

Table 3.15: Estimates of soil erosion rates

Land-use categories	Soil erosion rate (tonnes/ha/yr)
Well-managed forest land	5–10
Well-managed paddy terraces	5–10
Well-managed maize terraces	5–15
Poorly-managed sloping terraces	20–100
Degraded rangelands	40–200
Source: CBS (1998)	

According to meteorological data, the Churia hills receive much more intense rainfall than the middle and high mountains. Owing to weak geological formations, such as shallow and coarse soils and loosely compacted rocks, the Churia hills are more vulnerable to rainfall than the other two hill areas. As a result, the bare slopes of the Churia hills are readily exposed to degradation every rainy season. Conversely, flooding, sediment deposition, and river cutting during the rainy season have affected the Terai plains. It is observed that intense soil loss from the Churia hills takes place during the pre-monsoon season when there is less vegetative cover. Most of the Churia foothills are ploughed. Studies indicate that 60–80% of all annual soil loss occurs during the pre-monsoon season (Schreier et al. 1995; Ries 1991; DSCWM 1999).

Plate 6: Farmers need training on sustainable soil fertility management techniques *(ICIMOD)*

The intensity of soil erosion also differs between cultivated terraces and grassland. A study carried out in the Yarsha Khola watershed in the middle hill district of Dolakha showed that soil loss from cultivated terraces was 2.5-16.4 tonnes/ha/yr and from grassland was 0.7-8.7 tonnes/ha/yr (DSCWM/PARDYP — ICIMOD 1998). However, erosion rates in excess of 200 tonnes/ha/yr are common in grazing lands below 1,000 m where there is overgrazing, causing gully erosion (Carson 1992).

According to a study carried out by Carson (1985), erosion from very steep slopes where shifting cultivation is practised is 100 tonnes/ha/year where there is absence of measures for soil conservation. At the same time studies done by Wymann (1991) and Shah and Schreier (1994) found that while erosion and leaching on slopes of upland terraces are factors responsible for the decline of soil fertility, farmland in low-lying areas has benefited from these processes.

(b) Status of nutrients in the soil

Out of 9,827 farmland soil samples collected and analysed by five Regional Soil Testing Laboratories and the Soil Testing and Service Section of the Department of Agriculture in 1998/99, 48.2% of the samples were low and 40.2% were medium in nitrogen content (DoA 2000). Similarly, out of 7,520 soil samples analysed, 64% had low organic matter content. As nitrogen and organic matter are required for plant growth, these figures reveal a serious soil infertility problem on Nepal's farmlands. The potassium content, however, was at medium to high levels, and only 35% of the samples analysed for phosphorus showed low levels. The main micronutrient deficiencies in the soil were zinc, manganese, molybdenum, copper, iron, and boron. In particular, paddy soil was deficient in zinc. Overall the results are indicative of the deficient status of nutrients on Nepal's farmlands.

Of soil types, red soils are notorious for sheet and gully erosion because of low infiltration rates and a tendency towards surface crusting. Pine forests are much more vulnerable to landslide hazards than broadleaved forests. There is no undergrowth in pine forests, and this results in high surface runoff, gullies, and landslide scars, whereas broadleaved forests usually have a dense protective understorey.

3.2.4 Impacts

The impacts of soil degradation are many and all are closely related to environmental degradation. One of the direct impacts of soil degradation is the loss of fine topsoil (Plate 7). There is also depletion of organic matter and plant nutrients along with the topsoil, which ultimately affects soil fertility. It is estimated that a loss of soil at the rate of 5 tonnes/ha is equivalent to the loss of 75 kg/ha of organic matter, 3.8 kg/ha of nitrogen, 10 kg/ha of potassium, and 5 kg/ha of phosphorus (Carson 1992). The major rivers across the country carry away thousands of tonnes of sediment annually. The average annual weight of sediment per unit area affected deposited by various rivers in Nepal is shown in Table 3.16.

Plate 7: Siltation problem in a lake resulting from gully erosion deposits *(ICIMOD)*

Table 3.16: Sediment yields from some of the main rivers

River	Location/Region	Rate (tonnes/ km²/yr)
Tamor	East	8,200
Sun Koshi	Central and East	3,970
Bagmati at Chovar	Kathmandu Valley, Central	3,030
Trisuli	Betrawati, Central	2,750
Karnali	Chisapani, Far West	5,100
Source: CBS (1998)		

Landslides are another important factor in soil degradation (Plate 8). Landslides occur almost every year in every part of the country, resulting in the loss of land and lives. Table 3.17 shows the loss of life and effects on land and families due to erosion, landslides, and floods in different years. Roads, trails, bridges, and property are also damaged or destroyed.

The fertility of soil has decreased tremendously because of erosion of the topsoil as well as extensive siltation on farmland because of floods. The Ninth Plan has realised that crop productivity has declined because of soil degradation caused by overuse of soil for cropping with inadequate supplies of manure or fertiliser. The impact appears to be much more serious among poor farmers who

Table 3.17: Effects of erosion, landslides and floods on land and families

	1987	1990	1991	1992	1993	1994	1998	1999
Number of families affected	96,151	5,165	1,621	545	85,254	3,697	33,549	2,846
Degraded land area (ha)	18,860	1,130	280	140	5,580	390	326	69.5
Number of human deaths	391	307	93	71	1336	49	273	97
Source: MOHA (1999); DPTC (1997)								

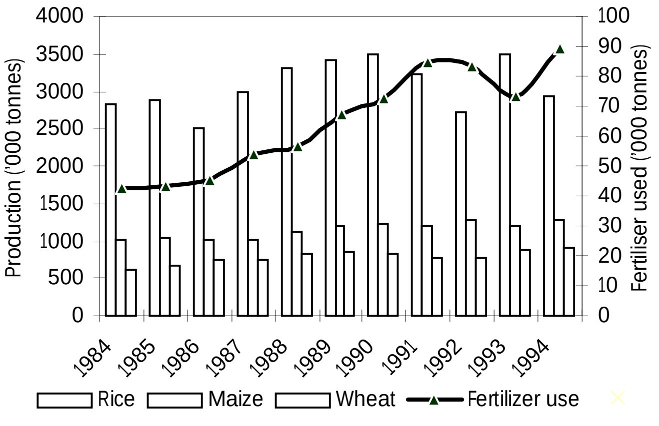
Plate 8: Massive land degradation: a big challenge *(ICIMOD)*

mostly cultivate marginal lands on steeper slopes.

As noted earlier, the demand for fodder and leaf litter is on the increase for the growing number of livestock in the country. The collection of leaf litter and fodder from the forest has also increased, causing depletion of nutrients in many forests, especially in the middle hill region.

Among the countries of South Asia, fertiliser use for farming by Nepalese farmers is low. Further, because of widespread ignorance about the proper use of fertilisers, their use has little positive impact on the productivity of the soil (Figure 3.13). Map 3.5 presents the average quantity of fertiliser used per hectare by district, it ranges from less than 10 to more than 100 kg. Case studies carried out by Tamang (1991) show that the organic content of the soil is low, and this can be corrected by use of compost.

Figure 3.13: Annual production of major food grains and fertiliser used



Up until 1994, import and distribution of fertiliser was controlled by the government's agriculture inputs corporation (AIC). In 1994 import by private firms commenced and since that time there are no data for total fertiliser inputs.

Source: MoF (2000); MoA (1999)

3.2.5 Responses

(a) Existing policy responses

- Soil degradation is perhaps the greatest impediment to development in Nepal (Plates 9 and 10). Attempts so far made at government level to conserve soil resources began with the establishment of the Department of Soil Conservation and Watershed Management (DSCWM) in 1974. The activities of DSCWM, as directed by the policies of the Master Plan for the Forestry Sector Nepal (MPFS), are as follow.
  - Ensure proper land use by rational land use planning
  - Implement integrated package programmes that include vegetative, agronomic, and water management measures to tackle soil erosion problems, taking the sub-watershed as the

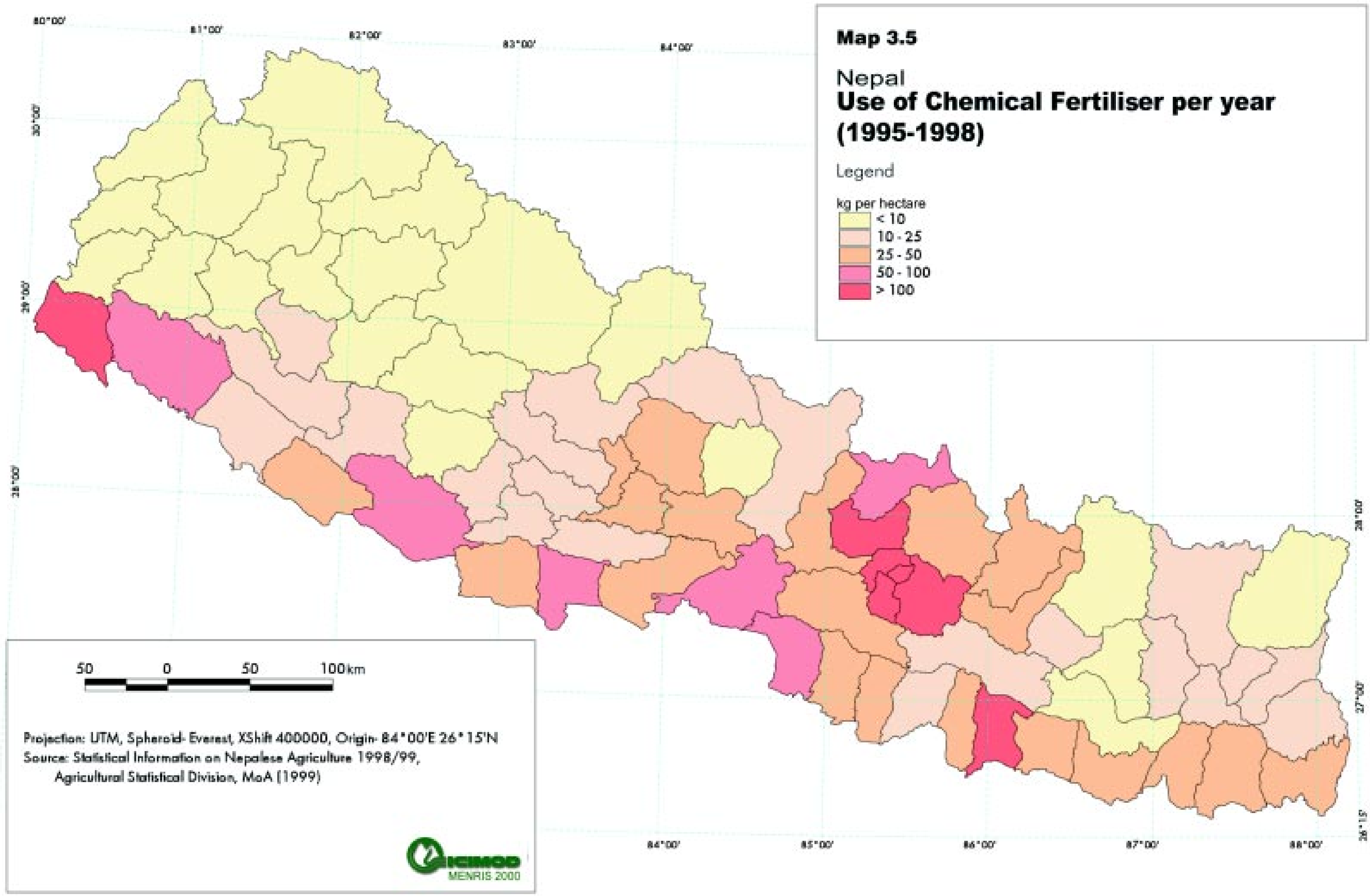

Map 3.5
Nepal
Use of Chemical Fertiliser per year
(1995-1998)
Legend
kg per hectare
< 10
10 - 25
25 - 50
50 - 100
> 100
50 0 50 100km
Projection: UTM, Spheroid- Everest, XShift 400000, Origin- 84°00'E 26°15'N
Source: Statistical Information on Nepalese Agriculture 1998/99, Agricultural Statistical Division, MoA (1999)
ICIMOD
MENRIS 2000

Plate 9: Road construction for regional integration, but costs are high in terms of environmental protection *(ICIMOD)*

unit of planning and management
- Establish and maintain linkages and networking with all other related sectors such as forestry, agriculture, livestock, water resources, roads, and so on
- Protect watersheds near hydroelectric dams and irrigation systems through plantation and other conservation techniques
- Focus on conservation activities in the Churia hills and other marginal lands
- Develop and promote appropriate conservation technologies
- Mobilise people's participation in the implementation of soil conservation activities

Plate 10: Bare land exposed to the sun is most affected by gully and sheet erosion *(ICIMOD)*

• Another milestone attempt was the formulation of the Soil and Watershed Conservation Act (1982) and its Regulations (1984) to protect the watersheds in the country. But these legal instruments are very restrictive and therefore have not been implemented. At present DSCWM is introducing a process to amend these laws.

• DSCWM has realised that the involvement of local people is essential in order to conserve soil as well as to address the soil degradation problem. Accordingly, DSCWM is implementing its programmes through people's participation by forming local community user groups as given in Box 3.1 and Plate 11.

• One of the successful policy initiatives that has a direct bearing on addressing soil degradation is community forestry. Its aims are to manage forest resources and use forest products by involving local communities. According to the Department of Forests, until February 2000, more than 650,000 ha of public forests had been given to local forest user groups to be managed as community forests.

• Local control of community-managed forests has led to increases in productivity and biomass because of strict protection from fires, free grazing, and uncontrolled cutting. These protection activities have encouraged natural regeneration of forest cover and helped stabilise reachable slopes. Because of the increased forest cover, the water regime (both yield and quality) has improved at micro-watershed level (Mathema et al. 1998).

• The long-term Agricultural Perspective Plan (APP) has identified fertiliser input as a major contributing factor to accelerating agricultural growth. The Ninth Plan (NPC 1999) recognised that there is now a need to have sound soil management programmes to maintain soil quality and fertility. The Plan also envisages the formulation of a Fertiliser Act and the establishment

Box 3.1: Programmes of DSCWM

In order to implement the Soil Conservation and Watershed Management Programme, DSCWM is implementing the following activities.

- **Land-use planning:** watershed management plans, sub-watershed management plans, and technical services for land-use development
- **Land productivity conservation activities**: on-farm conservation, grass plantation, fodder/fuelwood/fruit tree plantation, agroforestry, and greenbelt/shelterbelt establishment
- **Natural hazard prevention activities:** gully treatment, landslide treatment, torrent control, stream-bank protection, degraded land rehabilitation through bioengineering methods
- **Infrastructure protection activities:** slope stabilisation, roadside erosion control, trail improvement, canal protection, and water source conservation
- **Community soil conservation activities**: extension education, demonstration plots, training, study tours, local-level workshops, and exhibitions

Adapted from DSCWM (1998)

of a Fertiliser Unit at the Ministry of Agriculture.
- As per the obligations of being a signatory to the United Nations Convention to Combat Desertification, the Ministry of Population and Environment is in the process of preparing a National Action Programme to address the issues of land degradation and desertification. It is envisaged that the preparation of this programme and its subsequent implementation will bring about collaborative efforts from various agencies and stakeholders for better land husbandry in Nepal.

Plate 11: Land is being abandoned and marginalised *(ICIMOD)*

The trend in policy development in soil conservation and watershed management is shown in Table 3.18.

(b) Nepal's signature on international conventions and treaties

Nepal has signed various international conventions and treaties related to conservation of soil as shown in Table 3.19.

3.2.6 Conclusion

(a) Gaps

The following are crucial gaps in knowledge and information about soil degradation issues.
- There is no good information base on different dimensions of the soil. Whatever information and data are available are either patchy or location or topic specific. Some of the data gaps are lack of detailed mapping of soil structure at the district level; lack of information on loss of soil due to wind erosion, salinisation, and soil pollution; and magnitude of soil erosion and fertility losses by spatial location, type of cultivation, and land-use categories. Studies are required to

Table 3.18: Trends in policy development in soil conservation and watershed management

Period	Policy
1974 - 1980	Department of Soil Conservation and Watershed Management established; soil conservation works carried out by the government; no involvement of local people; focus on engineering structures
1980 -1985	Village leaders involved in the planning of soil conservation activities; Soil and Watershed Conservation Act (1982) and its Regulations (1984) formulated
1986 - 1990	Policy of working in prioritised small watersheds implemented; policy of involving local users in soil conservation and community forestry; formulated Master Plan for Forestry Sector implemented from 1989 onwards
1991 - 1994	Sub-watershed planning institutionalised; involvement of local user groups made mandatory; focus on bio-engineering
1995 - present	Local institution and capacity building, cost sharing, integrated community development, and income generation the main focus of policy and programmes

Table 3.19: International conventions and treaties on soil conservation

Conventions	Date	Nepal's Signature	Main objective	Major obligation
Plant Protection Agreement for South East Asia and the Pacific Region	27 Feb 1956	12 Aug 1965	Prevent introduction and spread of destructive plant diseases and pests	Regulate trade of plants and plant products
Convention on Biological Diversity	5 Jun 1992	15 Jun 1992	Ensure conservation and sustainable use of biological resources	Prepare and implement national strategies for the conservation of biodiversity
UN Convention to Combat Desertification	17 Jun 1994	12 Oct 1995	Combat desertification	Prepare national action plan and implement programmes for poverty alleviation

cover as many dimensions of the soil problem and as many geographical areas as possible so that acute soil issues can be addressed.

- Thorough economic analysis of soil erosion issues is lacking. Such an analysis is needed to justify investment in soil conservation measures.
- A common forum is needed for different organisations working on various aspects of soil. It is essential to facilitate allocation of work among different organisations to monitor and assess different aspects of soil degradation, to prioritise studies, and for data exchange.
- Recording of shifting cultivation areas and shifting cultivators is required in both hard copy and tabular forms. This would help formulation of specific programmes to conserve such areas.

(b) Recommendations

- There is severe population pressure on available farm land and, as a result, even steep slopes have been used for cultivation. Likewise, livestock have put immense pressure on forests and grasslands, leading to soil erosion. Therefore, population control naturally remains a crucial and overriding concern. Policies to minimise unsustainable use of land should also be formulated. This implies using the land according to its capability.
- Fundamental changes in management are needed to sustain soil nutrients in the long run. These will require a decrease in biomass removal and additional inputs into the soil. For areas of increasing acidity, limestone sources will have to be located and processed for application as a

soil amendment. Programmes are urgently needed to promote the use of a combination of organic and inorganic fertilisers to capture the synergistic relationship that exists between them.

- As most soil loss from cultivated land occurs during the pre-monsoon season, specific programmes are needed to protect the soil at this time. Some technical solutions are zero/minimum tillage, mulching, hedgerows, and maintaining green land cover.
- Soil degradation can be greatly lowered by efficient management of watersheds using integrated soil fertility management systems in combination with alternative land uses such as agroforestry, horticulture, pasture management, community forestry, and leasehold and private forestry.
- Off-farm employment can be promoted through environmental regenerative activities such as afforestation, management of degraded lands, agroforestry, horticulture, and so on. There are cases in which degraded lands have been effectively rehabilitated by local user groups as income-generating activities. The Pereni sub-watershed of Dang district is a good example (Box 3.2). Thorough and critical understanding of such cases can form the basis for the development of replicable action programmes.
- Promotion of low weight/volume and high-value products should be given high priority. Instead of prescribing broad guidelines, it is necessary to develop location-specific integrated activities with a focus on stability of the total production system. A participatory planning approach is needed to achieve this. Moreover, adequate infrastructural support is a prerequisite.
- Rainfall induced topsoil erosion is greatly increased by human activities and better land management could significantly reduce this form of erosion. However, mass wasting processes are not usually directly related to human activities and human intervention to reduce mass wasting can be very expensive and frustrating. “Landslide control with expensive structural measures is not appropriate and economically feasible unless it is necessary to protect nationally important assets” (Sthapit1989).
- From an economic perspective, soil erosion has high environmental costs and therefore there is a need to invest more in erosion control measures to achieve true economic benefit. The monetary value of environmental and economic damage from erosion represents the potential benefits from soil conservation measures. The estimates obtained could be taken as the amount of investment that can be put justifiably into soil conservation programmes.
- The resources to be allocated to DSCWM should be adequate to cover the magnitude and seriousness of the problem. However, even if more resources are somehow allocated, unless

Box 3.2: Pereni sub-watershed, Dang

Pereni sub-watershed (about 650 ha) located in Dang district was completely degraded with exposed red soil and was heavily scarred with gullies when the District Soil Conservation Office started rehabilitation activities. These activities included agroforestry, grass plantation, conservation plantation, gully plugging, irrigation canal improvement, and improved agronomic practices.

The local community was impressed by the success of these rehabilitation measures. The government encouraged the farmers to manage these areas and a soil conservation user group was formed. The user group is now independently managing the area and is making money through the sale of grass as well as grass seeds and cuttings. The local people have also planted improved grasses on their own land and the availability of grass has given a tremendous boost to livestock raising which is generating income for farm households.

The development of Pereni sub-watershed was achieved by encouraging the participation of local people through demonstration and training. Pereni exemplifies how beneficial outcomes can be derived from degraded land rehabilitation.

Adapted from DSCO/Dang (1991) and Wagley (1995).

population pressure is reduced and the economy can provide sustainable economic alternatives, the efforts to control soil degradation will not be worthwhile.

(c) Emerging issues

The following are the major emerging issues related to land resources.

- Land degradation caused by frequent landslides on the hill slopes and flash floods in the lowlands of the Terai
- The expansion of agricultural land over sloping areas, encroachment upon forest areas
- Diminishing fertility of agricultural land due to loss of topsoil
- Bank erosion by rivers
- Increasing dependency on agriculture
- Skewed distribution of landholdings
- Uncontrolled land-use development

3.2.7 Proposed Project

A cost analysis for one proposed project related to soil degradation is given below.

Project 1: Farmers' Training on Soil Fertility Management

Executive and promoting organisation:	Department of Agriculture, Department of Soil Conservation & Watershed Management and Department of Livestock at district level
Implementing organisation:	Local NGOs and CBOs working in related fields
Duration:	5 years
Location:	District Offices
Cost:	The total estimated cost for 55 districts for 5 years is US$ 1.4 million. This covers the cost for training – including logistics, a training package, planning, and monitoring and evaluation
Expected outputs:	The proposed training programme will produce a cadre of 27,500 farmers trained in sustainable soil fertility management techniques. These farmers will, in turn, train other farmers in their communities. The training programme is expected to contribute to conservation and enhancement of soil fertility on farmlands and ultimately lead to poverty reduction through increased farm production and income.
Methodology:	One training programme including at least 20 farmers in each of 55 districts for 5 days, 5 courses per year per district (well-trained farmers will be used as resource persons in each district.)

References

Carson, B. (1985) *Erosion and Sedimentation Processes in the Nepalese Himalaya*, *ICIMOD Occasional Paper No. 1*. Kathmandu: ICIMOD

Carson, B. (1992) *The Land, the Farmer and the Future – A Soil Fertility Management Strategy for Nepal, ICIMOD Occasional Paper No. 21*. Kathmandu: ICIMOD

CBS (1998) *A Compendium on Environmental Statistics 1998, Nepal*. Kathmandu: CBS

CBS (1999) *Statistical Year Book of Nepal*. Kathmandu: CBS

DoA (1999) *Annual Report of Soil Science Programs 1998/99*. Kathmandu: DoA, Crop Development Division, Soil Testing and Service Section

DFRS (1999a) *Forest and Shrub Cover of Nepal, 1994*. Kathmandu: DFRS

DFRS (1999b) *Forest Resources of Nepal*. Publication No. 74. Kathmandu: DFRS, DoF

DoR (1999) *Nepal Road Statistics NRS* - 1998. Kathmandu: DoR

DPTC (1997) *Annual Disaster Review 1996*. Kathmandu: Water Induced Disaster Prevention Centre

DSCO/Dang (1991) *Narayanpur Pereni Soil Conservation Area: An Introduction*. (Brochure in Nepali). Tulsipur, Dang: District Soil Conservation Office

DSCWM/PARDYP-ICIMOD (1998) *Soil Erosion Studies in Jhikhu Khola and Yarsha Khola Watershed* (Annual Technical Progress Report 1997). Kathmandu: DSCWM and ICIMOD

DSCWM (1998) *An Introduction to Soil Conservation and Watershed Management in Nepal.* (Brochure). Kathmandu: DSCWM

DSCWM (1999) *Erosion Process Monitoring at Tistung of Kulekhani Watershed* (Annual Report 1998). Kathmandu: DSCWM

ICIMOD (1998) *Newsletter No. 32*

Joshy, D.; Pandey, S.P.; Maskey, R.B. (1997) 'Status of Land Degradation in Nepal'. In: Ghimire, M.P.; Uprety, B. (eds) *Combating Desertification: Report of the National Seminar on Desertification and Land Improvement*, pp41–50. Kathmandu: MoPE

Laban, P. (1979) *Landslide Occurrence in Nepal, IWM/WP/13*. Kathmandu: FAO/HMGN/UNDP, Integrated Watershed Management, Torrent Control and Land Use Development Project

Mathema, P.; Shrestha, K.B.; Sthapit, K.M. (1998) *Community Forest Management in Nepal: Implications for Policy and Human Resource Development*, paper presented at the Regional Workshop on Participatory Forest Management: Implications for Policy and Human Resource Development, 7–12 May 1998, Kunming, China

MPFS (1988) *Master Plan for Forestry Sector Nepal. Soil Conservation and Watershed Management Plan.* Kathmandu: MFSC

MoA (1999) *Statistical Information on Nepalese Agriculture 1998/1999*. Kathmandu: HMGN, MoA, ASD

MoHA (1999) *Loss of lives by Disasters (1983-1999)*. Kathmandu: MoHA, K. B. Disaster Relief Section

MoPE (1998) *Population Projections for Nepal 1996–2016, Volume I*. Kathmandu: MoPE

Sharma, H.B.; Gautam, R.P. (1999) *Nepal District Profile.* Kathmandu: National Research Associates Nepal (NRAN)

NPC (1999) *The Ninth Plan (1997–2002).* Kathmandu: NPC

PARDYP (1998) *Hydrological and Meteorological Data of Yarsha Khola Watershed.* Kathmandu: ICIMOD/DHM/TU/University of Berne

Raut Y. (1997/98) *A Handbook of Animal Husbandry, Part I: Pasture Production.* Kathmandu: MoA, Department of Livestock Services

Ries, J. (1991) 'Man Made Soil Erosion in the High Mountain Region: A Case Study of Bamti/ Bhandar.' In Shah, P.B.; Schreier, H.; Brown, S.; Riley, K.W. (eds) *Soil Fertility and Erosion Issues in the Middle Mountains of Nepal*, pp 135–151. Kathmandu: ICIMOD and UBC

Schreier, H.; Brown, S.; Shah, P.B. (1995) 'Identification of Key Resource Issues: Discussion and Recommendations'. In Schreier, H., Shah, P.B.; Brown, S. (eds) *Challenges in Mountain Resource Management in Nepal - Processes, Trends and Dynamics in Middle Mountain Watersheds*. pp. 247–252. Kathmandu: ICIMOD and UBC

Shah, P.B.; Schreier, H. (1994) 'Soil Fertility Issues under Irrigated and Rain-fed Agriculture in the Middle Mountains of Nepal'. In Shengji, P. Karki, S. (eds) *Proceedings of an International Workshop on Rehabilitation of Degraded Lands in Mountain Ecosystems of the HKH Region*, pp34–42. Kathmandu: ICIMOD and UBC

Sthapit, K.M. (1989) *Soil Conservation Status in Nepal*. Lalitpur: S. Sthapit

Tamang, D. (1991) 'Indigenous Soil Fertility Control Techniques in the Jhikhu Khola Watershed.' In Shah, P.B.; Schreier, H.; Brown, S.; Riley, K.W. (eds) *Soil Fertility and Erosion Issues in the Middle Mountains of Nepal*, pp121–127. Kathmandu: ICIMOD and UBC

Tuladhar, B (1999) *Hazardous Waste Management Nepal Country Report*: Kathmandu: WHO

TPC (1998) *Nepal Overseas Trade Statistics*. Kathmandu: Trade Promotion Centre

Wagley, M.P. (1995) 'Status of Watershed Management in Nepal'. In Sharma, P. N.; Wagley, M.P. (eds) *The Status of Watershed Management in Asia*. PWMTA-FARM Field Document No. 1. GCP/ RAS/161/NET-RAS/93/062, Participatory Watershed Management Training in Asia (*PWMTA*). Project Kathmandu: FAO

Wymann, S. (1991) 'Land Use Intensification and Soil Fertility in Agricultural Land: A Case Study in the Dhulikhel Khola Watershed'. In Shah, P.B.; Schreier, H.; Brown, S.; Riley, KW. (eds) *Soil Fertility and Erosion Issues in the Middle Mountains of Nepal*, pp 253-259. Kathmandu: ICIMOD and UBC

3.3 SOLID WASTE MANAGEMENT

3.3.1 Introduction

Solid waste is an inevitable by-product of human activities. In the past, this was not a major problem because almost everything was reused or recycled and whatever remained was taken care of by nature. However, the introduction of new materials and changing consumption patterns, especially in urban areas, have resulted in increasing volumes of waste and, as a result, breakdown of traditional systems of waste management has taken place. In Nepal, as in many other developing countries, these changes have taken place rapidly over the past few decades, while the government and the people have failed to realise their serious implications and the urgent need to address them. As a result, many cities in Nepal are now suffering from the adverse impacts of unmanaged waste. The problem is acute, particularly in large cities like Kathmandu, Lalitpur, and Pokhara where improper management of waste has led to environmental pollution, public health hazards, and adverse effects on an urban economy that depends heavily on tourism.

3.3.2 Pressure

Urbanisation in Nepal is characterised by rapid and haphazard growth, and this has exerted tremendous pressure on the urban environment as well as on the capacities of the government and the people to manage this change. One of the most visible indicators of this growth is the heaps of garbage that can often be seen littering the city streets or at dump sites on river banks and in other public places (Plates 12 and 13).

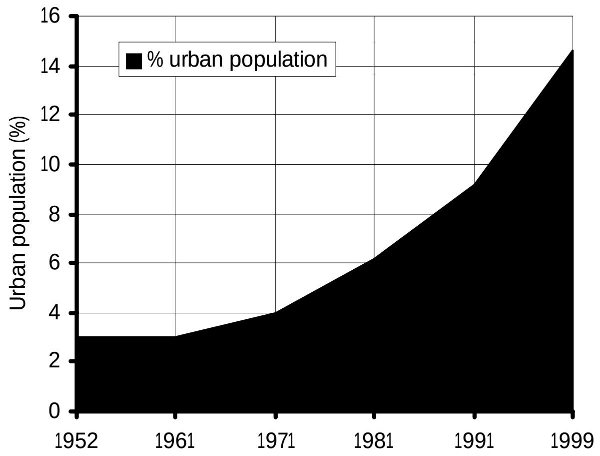
Plate 12: Garbage dumped into the river polluting the water and detracting from its aesthetic value *(ICIMOD)*

Plate 13: Think of the health of people living near such a haphazard garbage site! *(B. Pradhan)*

With about 15% of the total population living in towns (municipalities with over 9,000 persons), Nepal is still predominantly a rural country (Figure 3.14). However, the rate of urban growth, which at 6.5% per annum is the highest in South Asia, is a major concern. In 1952-54, only three per cent of the total population of 8.2 million resided in urban areas, of which 83% lived in the Kathmandu Valley. In the subsequent population census years of 1961, 1971, and 1981, the number of people living in municipalities grew by 41, 38, and 107% respectively. Between 1981 and 1991, the total municipal population grew by 77% while the rural population grew by only 17% (CBS 1997). It should, however, be noted that some of the smaller municipalities in Nepal have settlements with rural characteristics.

The Kathmandu Valley, which has the capital city of Kathmandu along with four other municipal towns, Lalitpur, Bhaktapur, Kirtipur, and Madhyapur-Thimi, is the main urban area of Nepal. Although its relative share of the total urban population in Nepal is declining, its population is still growing at an increasing rate. In the 1970s, the Valley's population grew at an average annual rate of 4.6%, while in the 1980s the annual growth rate went up to 6%. Assuming the same growth rate in the 1990s as in the 1980s, the Valley's urban population has now crossed the one million mark. Kathmandu, which is the largest and fastest growing city within the Valley, now has a population of over 700,000. In the 1980s, Pokhara, with an annual average growth rate of 7.41%, was the fastest growing city in the country.

Figure 3.14: Urbanisation in Nepal



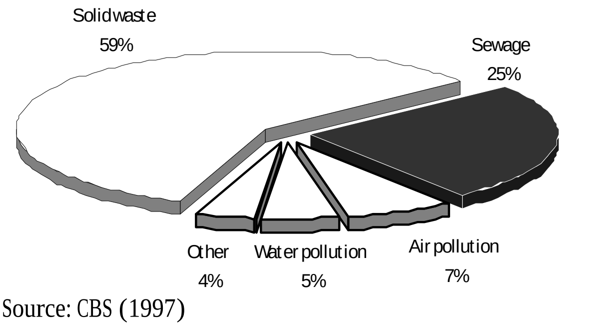
Source: CBS (1999)

With the exception of the Kathmandu Valley's cities and the city of Pokhara, urban growth has mainly centred on the towns of the Inner Terai and the Terai areas in the southern part of the country because of the productive resource base and better transport linkages. In 1987, it was estimated that about 60% of the total urban population was in the Inner Terai and the Terai compared to 17% in 1952-54 (Sharma 1987).

Migration to cities, especially from the hill areas of Nepal, in search of jobs, education, and other opportunities, is the main cause of rapid growth in the urban population. A survey conducted in 1996 revealed that 41% of the urban population consisted of lifetime migrants (CBS 1997). Among them, 45.6% were farmers prior to migration, while 19.6% were students and 15% were service holders. This indicates that the main cause of rapid urbanisation in the country is the inability of villagers in the rural areas to sustain their livelihoods with agriculture only.

Although urbanisation in itself is not necessarily a problem as it promotes economic activities and alleviates pressure on land resources, haphazard and unplanned urban growth generally invite many environmental problems such as public space and river bank encroachment, air and water pollution, and solid waste generation. Among these, unmanaged solid waste seems to be the most visible problem. Figure 3.15 shows the results of a survey of 3,980 urban residents from all over Nepal; 59% considered unmanaged waste to be the main environmental problem in the cities (CBS 1997) and 25% domestic sewage.

Figure 3.15: Public opinion on environmental problems in urban areas



Source: CBS (1997)

Changing consumption patterns and breakdown in the traditional systems of waste management also contribute to the problem of waste management in urban Nepal, especially in the city of Kathmandu. Until a few decades ago, almost all of Kathmandu's waste was organic and was recycled to produce compost. In the traditional system, waste generated in households was either sold directly to farmers or placed in pits called 'saaga' ('saa' means compost and 'gaa' means pit in the Newari language) which were located in between the houses (Tuladhar 1996). Nowadays, the 'saagas' have vanished and the composition of municipal waste has also changed with the introduction of new materials such as plastics, paper, and glass. As a result, most people now dump their waste on the streets or in other public places and only a very small portion of the waste is recycled. A study by Manandhar et al. (1987) revealed that not a single ward in Kathmandu was free from solid waste and nearly three-fifths of the wards had solid waste heaps in over 84% of the total locations observed. The sharp increase in the use of chemical fertilisers also indicates that the practice of recycling waste to produce organic fertiliser has decreased and most people are using chemical fertilisers instead.

3.3.3 State and Impacts

Compared to other countries, Nepal still generates very little waste and most of what is generated is not hazardous and easily recyclable. Therefore, the increasing volumes of waste being generated would not be a problem if waste was viewed as a resource and managed properly. This, however, is not the case as most of the waste is just dumped in public places. This is causing problems related to environmental pollution and public health, especially in the big cities.

(a) Municipal waste

Households are the main sources of solid waste in Nepal. Based on the figures estimated for the urban population and the assumption of per capita waste generation ranging from 0.25 to 0.5 kg/day depending on the size of the city (Table 3.20), it is estimated that, in 1997, the residents of the country's 58 municipalities generated approximately 304,848 tonnes of municipal waste. This accounts for about 83% of all solid waste generated in Nepal. In comparison, agricultural waste accounts for 11% and industrial waste for 6% of the total solid waste.

Table 3.20: Per capita municipal waste generation

Municipality classes by population size	Estimated waste generation (kg/person/day)
Less than 20,000	0.25
20,001 to 50,000	0.30
50,001 to 100,000	0.35
100,001 to 400,000	0.40
More than 400,000	0.50

Source: Mishra and Kayastha (1998)

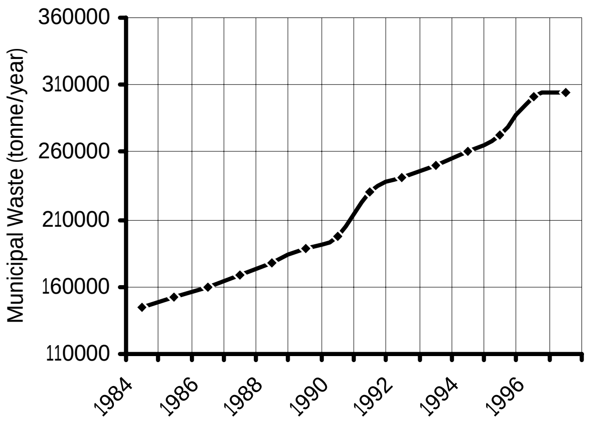
The amount of waste generated is closely related to the standard of living. Studies estimate that low income countries (per capita income below US$360 in 1978) generate around 0.5 kg, middle income countries (US$360 to 3,500 per capita) generate 1.5 kg, and high income countries (above US$ 3,500) generate about 2.75 to 4 kg/person/day (NPC/IUCN 1992). In Nepal, there are no in-depth studies about total amount and characteristics of wastes generated and most municipalities or waste generators do not keep records of the waste they produce.

A few studies prepared on waste generation in Kathmandu city indicate that the per capita waste generation is low compared to most other countries and that about two-thirds of the waste materials are organic. Lohani and Thanh (1978) estimated that the per capita waste generation rate in Kathmandu was 0.25 kg/day, GTZ (1988) that it was 0.4 kg/day, and Khanal (1993) 0.46 kg/day. On the high side, Rai (1990) estimated the rate to be 0.565 kg/day. Misra and Kayastha (1998) estimated that the per capita waste generation rate of Nepalese cities varied from 0.25 to 0.5 kg/day depending on the size of the city (Table 3.20). A recent survey estimated the average amount to be 0.48 kg/day (RESTUC 1999).

The estimated amount of municipal solid waste generated in 1999 by each of the 58 municipalities, based on the assumption that the urban population in the 1990s grew at the same rate as in the 1980s and the values shown in Table 3.20, is presented in Table 3.21 and Map 3.6. The table shows that, in 1999, about three million urban residents in Nepal generated an estimated 426,500 tonnes of waste, 29% of this in Kathmandu alone. Solid waste generation by ward of Kathmandu Metropolitan City (KMC) is shown in Map 3.7.

Figure 3.16 shows the waste generated by municipalities from 1984 to 1997 (at which time there were fewer municipalities).

Figure 3.16: Estimated amount of waste generated by municipalities, Nepal



Source: MLD (2000)

Table 3.22 shows that although the share of plastics and paper is increasing, two-thirds of waste materials are still organic. A survey done in Bhaktapur, which is not yet as fully influenced by modern culture as Kathmandu, indicated that 89% of the waste was organic, while the proportion of plastics was only 2% (Tuladhar and Ban 1997).

Very few studies have been carried out on the impacts of municipal waste on the surrounding environment and human health. One major impact of municipal waste is on the health value of rivers and the health of the street people working with waste. Throwing household waste into local streams has affected the quality of water in local streams as well as the aesthetic value of the cities of the Kathmandu Valley (Pradhan 1998) (Plate 14). A study of health hazards to municipal sanitary workers in Kathmandu (Rajbhandari 2000) indicates that scheduled caste people working with municipal waste particularly have become prone to health hazards on account of their lacking awareness of the changing pattern of waste and of not using protective measures while collecting it. Such impacts are also observed on their infants and children because they often carry them while working with municipal waste. Because there are no protective measures, such workers most likely carry the pathogens from their working places and may transmit them to other family members at home.

Plate 14: Garbage dumped along the river in the heart of Kathmandu *(ICIMOD)*

(b) Hazardous waste

Due to the low level of industrialisation and limited use of hazardous chemicals, such as pesticides and persistent organic pollutants, it is safe to say that Nepal probably generates very little hazardous waste compared to other countries. Hazardous waste is, however, a major concern because the small amount that is generated is not properly managed and policy-makers and society as a whole have not taken any steps to minimise the potential environmental and health risks associated with such waste.

The main types of hazardous waste generated in the country are medical waste, obsolete pesticides, batteries, and a few types of industrial waste. Tuladhar (1999a) estimated that a total of 6,521 hospital beds in Nepal generated approximately 500 tonnes of hazardous waste per year. Most of the waste is mixed with other garbage and is either dumped or burned in ordinary kilns.

Obsolete pesticides or pesticide containers can also be classified as hazardous waste. Currently, about 67 tonnes of hazardous obsolete pesticides are stockpiled in unsafe conditions at various

Table 3.21: Waste generated in municipalities (estimated)

S.N	Municipality	Popn (1991)	Growth rate (%)	Est. Popn (1999)	Est. Waste (tonnes/yr)	S.N	Municipality	Popn (1991)	Growth rate (%)	Est. Popn (1999)	Es (to
1	Kathmandu	421,258	6.00	671,421	122,534	31	Birendranagar	22,973	5.18	34,410	
2	Biratnagar	129,388	3.30	167,763	24,493	32	Tulsipur	22,654	4.00	31,004	
3	Lalitpur	115,865	3.79	156,026	22,780	33	Siraha	21,004	2.05	24,706	
4	Pokhara	95,286	7.41	168,806	24,646	34	Prithvinarayan	20,633	0.80	21,991	
5	Birganj	69,005	4.69	99,569	12,720	35	Panauti	20,467	0.54	21,368	
6	Dharan	66,457	4.66	95,672	12,222	36	Gaur	20,434	3.00	25,885	
7	Mahendranagar	62,050	3.54	81,961	10,471	37	Byas	20,124	3.50	26,499	
8	Bhaktapur	61,405	2.39	74,176	9,476	38	Bhimeshwor	19,259	1.40	21,525	
9	Janakpur	54,710	4.62	78,521	10,031	39	Lahan	19,018	3.28	24,620	
10	Bharatpur	54,670	7.07	94,426	12,063	40	Khandbari	18,756	0.92	20,182	
11	Hetauda	53,836	4.46	76,326	9,751	41	Bidur	18,694	0.95	20,163	
12	Nepalganj	47,819	3.46	62,774	8,019	42	Inaruwa	18,547	4.45	26,275	
13	Dhangadi	44,753	5.08	66,525	8,499	43	Kalaiya	18,498	2.79	23,053	
14	Butwal	44,272	6.96	75,840	9,689	44	Jaleshwor	18,088	1.23	19,946	
15	Damak	41,321	5.12	61,610	7,871	45	Dashrathchand	18,054	1.14	19,768	
16	Siddarthnagar	39,473	2.41	47,757	5,229	46	Kapilbastu	17,126	3.52	22,587	
17	Mechinagar	37,108	2.13	43,923	4,810	47	Dhankuta	17,073	2.12	20,193	
18	Madhyapur-Thimi	31,970	0.79	34,047	3,728	48	Waling	16,712	0.77	17,770	
19	Kirtipur	31,338	4.70	45,253	4,955	49	Amargadhi	16,454	1.86	19,068	
20	Ramgram	31,297	3.45	41,053	4,495	50	Narayan	15,728	1.18	17,276	
21	Gularia	30,631	3.77	41,185	4,510	51	Baglung	15,219	0.77	16,182	
22	Lekhnath	30,107	2.81	37,579	4,115	52	Bhadrapur	15,210	4.54	21,696	
23	Tribhuvannagar	29,050	3.49	38,224	4,186	53	Malangawa	14,142	3.02	17,943	
24	Itahari	26,824	2.96	33,874	3,709	54	Tansen	13,599	0.36	13,996	
25	Putalibazar	25,870	0.77	27,507	3,012	55	Ilam	13,197	3.05	16,783	
26	Tikapur	25,639	4.83	37,393	4,094	56	Banepa	12,537	1.75	14,404	
27	Ratnanagar	25,118	3.11	32,092	3,514	57	Dipayal	12,360	2.71	15,308	
28	Kamalamai	24,368	1.98	28,506	3,121	58	Dhulikhel	9,812	4.38	13,826	
29	Rajbiraj	24,227	3.95	33,029	3,617		**TOTAL**	**2,285,358**		**3,172,094**	
30	Triyuga	23,871	3.25	30,831	3,376						

Source: MLD (2000); CBS (1999)

Table 3.22: Composition of waste in Kathmandu

Components	% of waste (by weight)					
	1976[1]	1981[2]	1985[3]	1988[4]	1995[5]	1999[6]
Organic Materials	67.8	60.0	67.5	58.1	65.0	67.5
Paper	6.5	19.3	6.0	6.2	4.0	8.8
Plastics	0.3	3.6	2.6	2.0	5.0	11.4
Glass	1.3	3.4	4.0	1.6	1.0	1.6
Metals	4.9	3.4	2.2	0.4	1.0	0.9
Textile	6.5	5.3	2.7	2.0	3.0	3.6
Rubber and leather	0.0	0.0	0.0	0.4	1.0	0.3
Wood	2.7	1.6	0.0	0.5	3.0	0.6
Dust/construction debris	10.0	3.4	15.0	28.9	17.0	5.3

Sources:
1 Mean value of two samples taken at Thamel on 30/7/76 and at Bhonsiko Street on 3/8/76 (Tabasaran 1976)
2 Tabasaran and Bidlingmaier's report on the possibility of composting municipal waste in Kathmandu Valley (Mutz 1990)
3 Survey on waste generation in households and small shops in Kathmandu and Patan (Mutz 1990)
4 Survey of waste from six sites in Kathmandu conducted in May 1988 (Mutz 1990)
5 Survey conducted by NESS (Thapa and Devkota 1999)
6 Average of samples from seven sites (RESTUC 1999)

locations in the country (DoA 2000). The total consumption of pesticides in the country is approximately 55 tonnes of active ingredients per year (Manandhar and Palikhe 1999). According to a survey conducted in 1995, the most common pesticides used in Nepal were BHC, aldrin, and endosulfan. The survey also revealed that 38% of the farmers buried or burned old/unused pesticides, while 25% threw them in open dumps, 17.5% gave them to friends, 10.8% reused them, and 8.3% threw them into waste containers. Regarding the fate of empty pesticide containers, 46% threw them away, 26% burned them, 18% buried them, and 10% reused them to store cooking oil or drinking water (Dahal 1985). These data indicate that, although the amount of pesticides consumed in the country is relatively small, mismanagement of pesticide waste is a problem.

Used batteries are another source of hazardous waste because of the heavy metals they contain. All used wet batteries from vehicles are sent to India for recycling, while dry cells are normally disposed of with other municipal waste. Nepal consumes approximately 4.5 million dry cells per year. Assuming that each cell weighs 50 g, the total amount of dry cells disposed of per year is about 225 tonnes. In addition, about 10 tonnes per year of hazardous waste are generated from the battery manufacturing factories in the country.

3.3.4 Responses

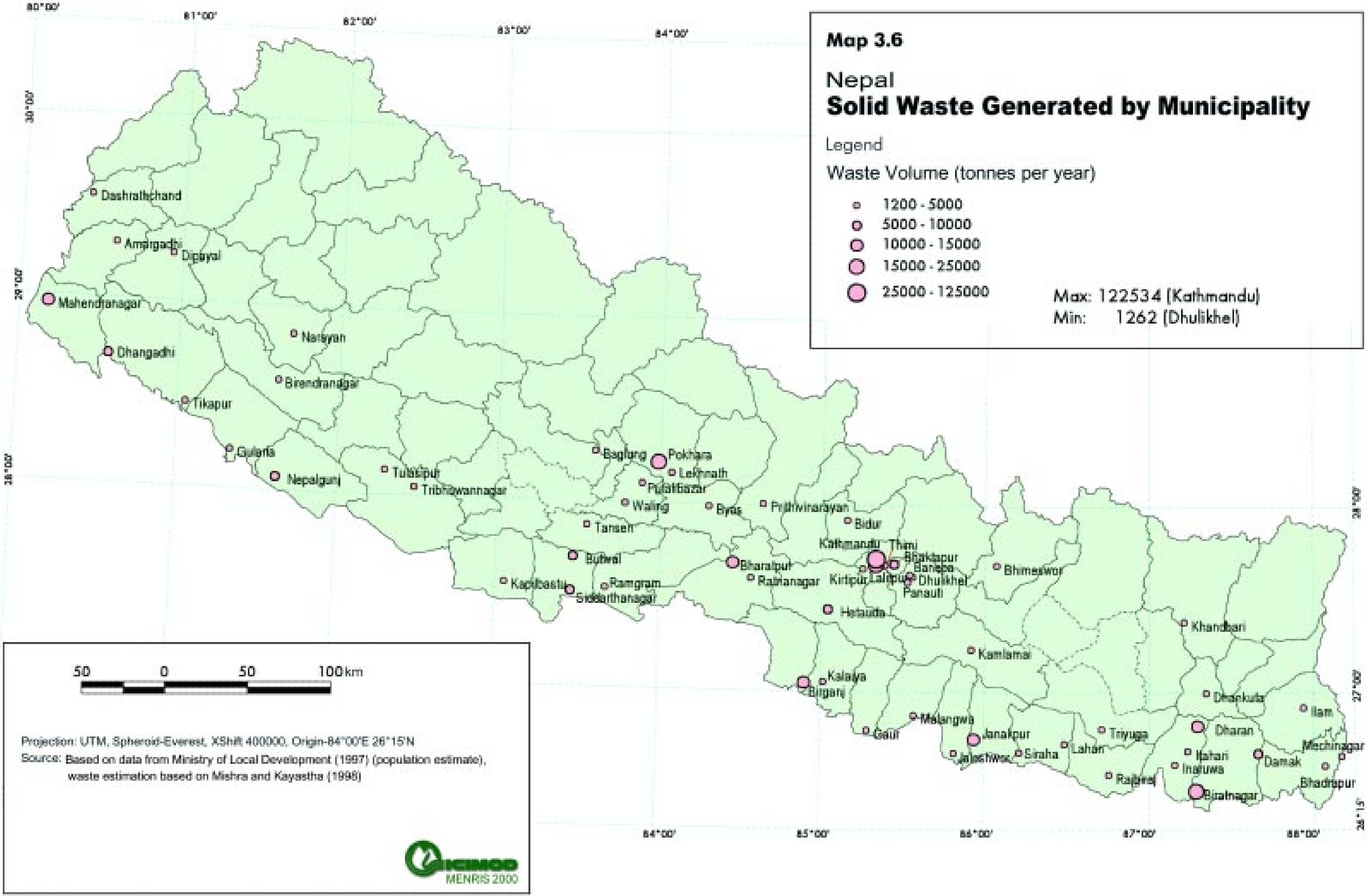
'Out of sight, out of mind', is the most common response to the problem of solid waste management in Nepal. The attitude of most people as well as of the authorities is to sweep the streets and dump the garbage in an area where no one will complain (Plate 15). Waste is often

Plate 15: No specific sites for garbage *(B. Pradhan)*

Map 3.6

Nepal

Solid Waste Generated by Municipality



Projection: UTM, Spheroid-Everest, XShift 400000, Origin-84°00'E 26°15'N

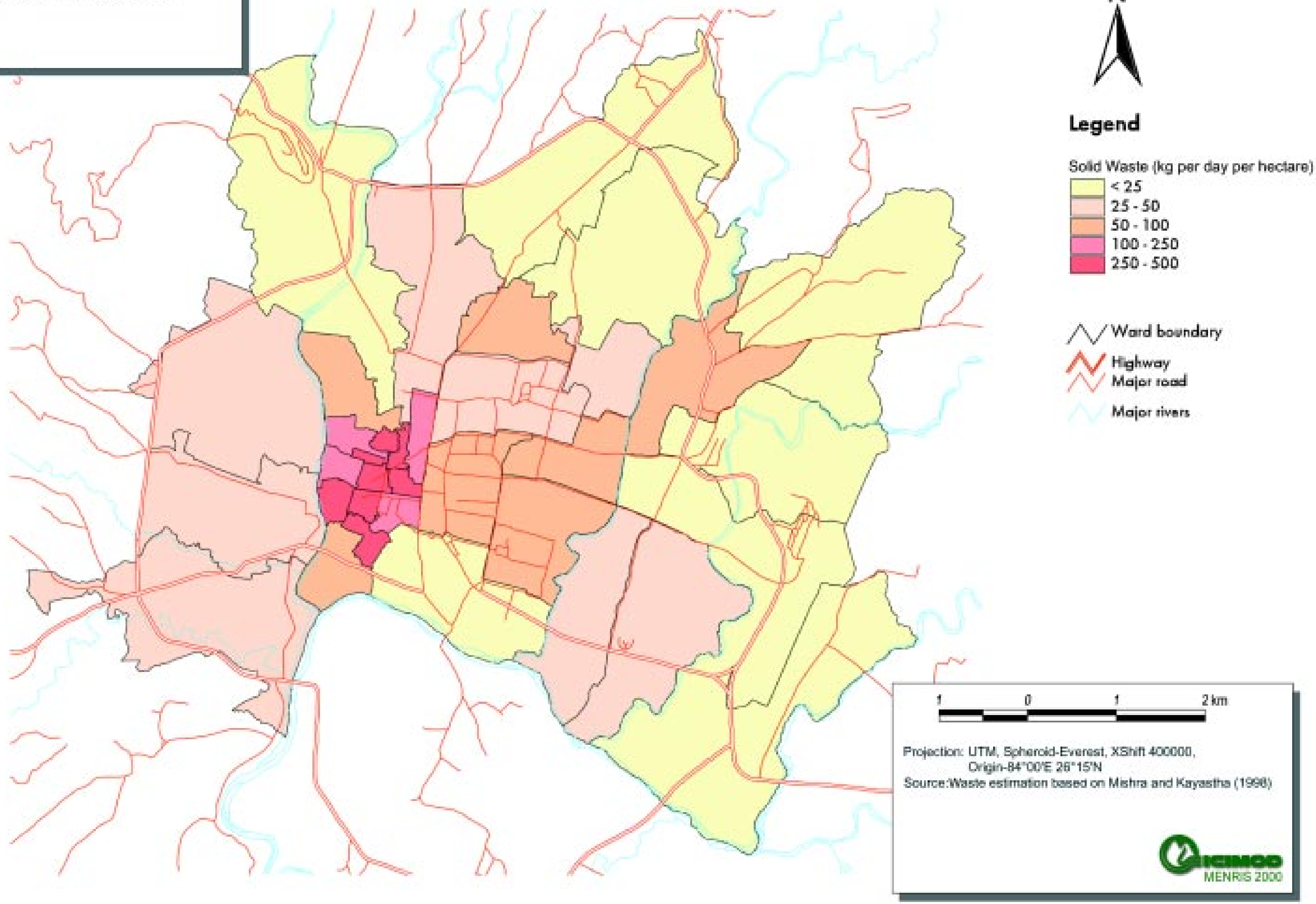
Source: Based on data from Ministry of Local Development (1997) (population estimate), waste estimation based on Mishra and Kayastha (1998)

ICIMOD MENRIS 2000

Map 3.7

Kathmandu Municipality

Solid Waste Generation by Ward



treated as a nuisance rather than a resource, and the long-term implication of poorly managed waste is not considered seriously. The country has formulated some policies on waste management, but implementation of these policies is clearly lacking. In recent years, however, the waste management crisis in Kathmandu has prompted local community groups and the municipalities to make some improvements. There is now an urgent need to build on these efforts and coordinate the activities of the government, municipalities, and local communities.

(a) Central government

The government started its involvement in waste management in 1980 following the implementation of the Solid Waste Management Project with the support of the German Government. The project established the Solid Waste Management and Resource Mobilisation Centre (SWMRMC) to manage Kathmandu's waste and introduced a modern waste management system. It also established a small compost plant at Teku and the Gokarna landfill site. Although the project was quite successful in managing Kathmandu's waste in the 1980s, the system collapsed when the project ended in 1993. The government was unable to provide the SWMRMC with the necessary support and there was little coordination between SWMRMC and the municipalities. The latter were also involved in waste management. Currently the SWMRMC is only a small unit under the Ministry of Local Development (MLD) and its role is not yet clear.

The MLD also has a National Council for Solid Waste Management, which is headed by the Minister for Local Development and includes representatives of all related ministries, municipalities, the private sector, and experts. The Council, however, is not active and has not met for several years.

In 1996, the government prepared a Solid Waste Management National Policy which had the following objectives.

- To make solid waste management simple and effective
- To minimise environmental pollution and adverse effects on public health caused by solid waste
- To mobilise solid waste as a resource
- To privatise solid waste management
- To obtain public support by increasing public awareness about waste management.

Although the National Policy was a good start on the part of the government to addressing the issue of waste management, it has not been followed up by plans and programmes. As a result, the policy has not yet been implemented.

The Ninth Plan (1997-2002) includes the following policy statements.

- Recycling will be promoted by motivating people engaged in the recycling business
- Make legal provisions for mobilising NGOs and the private sector effectively in the field of waste management

The only legislation directly related to waste management in Nepal is the Solid Waste (Management and Resource Mobilisation) Act (1987). Although this is a fairly good and comprehensive Act, it is now obsolete because it was created primarily to establish SWMRMC and to define its roles and responsibilities for managing the waste in Kathmandu. As SWMRMC is no longer responsible for managing Kathmandu's waste, the Act needs to be changed. The Local Self-Governance Act (1999) determines those responsible for waste management.

Nepal does not have any policies or legislation dealing with hazardous waste. The government has neither defined hazardous waste nor issued any standards for its management. Furthermore, it is not clear which government agency is responsible for dealing with issues related to hazardous waste. As a result, the country does not have a programme for hazardous waste management.

(b) Municipalities

The new Local Self-Governance Act (1999) makes the municipalities totally responsible for solid waste management. Even in Kathmandu, where the SWMRMC was previously involved in waste management, the municipalities have now taken over all responsibilities. Although this is a move in the right direction, most municipalities do not have adequate resources and technical expertise to manage their waste effectively.

The Local Self-Governance Act has increased the responsibilities of municipalities but abolished the octroi tax (levied on goods and vehicles entering into or passing through municipal areas) which was the main source for income of the municipalities. As a result, most municipalities are now struggling to mobilise resources just to meet their regular expenses. The municipalities of Nepal are therefore unable to spend enough on waste management, especially on capital investment for the purchase of equipment and the construction of infrastructure. Most municipalities are only involved in sweeping streets and dumping the waste along a nearby river or in a public place.

Kathmandu is the only municipality with a landfill site. Its Gokarna landfill site is, however, not environmentally safe because it does not have liners and leachate collection nor a treatment system. Currently 250 to 300 tonnes of waste from Kathmandu and Lalitpur are dumped, compacted, and covered with soil every day at the Gokarna landfill. Hazardous medical waste is also disposed of at the site.

The Gokarna landfill site is already full. The SWMRMC, which is responsible for developing a new site, has not yet been able to do so. The inability to develop an alternative to the Gokarna site is currently the main problem in managing Kathmandu's waste.

No municipalities, except for Kathmandu and Bhaktapur, have seriously pursued options for waste management other than dumping and landfill. Bhaktapur has operated a small compost plant, which has a capacity to process four tonnes waste per day. The plant, however, is currently processing less than one tonne per day because of poor management and marketing of compost. Since 1996, Bhaktapur has been selling compost at only NRs 0.37/kg although the cost of production is NRs 1.18/kg. Analysis of the plant, however, indicates that, with some simple improvements in composting techniques and management, the plant can sustain itself and can be a model for other municipalities in Nepal (Rai 1990; Mutz 1992; Tuladhar and Ban 1997). Kathmandu Metropolitan City (KMC) is currently operating a few small composting units. Although this is a positive step, their contribution is negligible as they handle less than one per cent of the total waste. Recently, KMC signed an agreement with a private party to construct a plant with a capacity of 300 tonnes/day to make fertiliser from all of Kathmandu's organic waste. The operation of this plant would go a long way to solving Kathmandu's waste problems.

Although the exact amount of resources allocated to waste management by municipalities is not known, the number of municipal staff involved in waste management indicates that most municipalities still do not consider solid waste management to be a priority sector in which a significant amount of investment is required. In Kathmandu, where the problem is most severe, the city spent NRs 91.2 million for waste management in 1997/98, which is equivalent to about NRs 11,000/tonne of waste managed. Table 3.23 shows that, whereas Kathmandu and Bhaktapur have allocated a significant amount of funds and staff for waste management, newly-formed municipalities like Kirtipur and Madhyapur-Thimi have very little resources for waste management.

The Municipal Association of Nepal (MUAN) and the Urban Development through Local Efforts (UDLE) project of GTZ are currently introducing a few programmes for training municipal staff

Table 3.23: Resources allocated to waste management in Kathmandu Valley's municipalities

Municipality	Estimated population (1999)	Staff for waste management	Residents per staff	Expenditure on waste management (1998/99) (NRs)	Expenditure per resident (NRs)
Kathmandu	671,421	1300	516	91,200,000	135.83
Lalitpur	156,026	189	826	13,000,000	83.32
Bhaktapur	74,176	174	426	8,573,446	115.58
Kirtipur	45,253	10	4525	1,500,000	33.15
Madhyapur	34,047	17	2003	500,000	14.69

Source: Tuladhar (1999a)

on waste management and raising awareness on waste management issues. The Town Development Fund occasionally provides grants and loans for municipalities that want to invest in equipment or facilities related to waste management.

(c) Local communities

A survey done in 1996 indicated that most urban residents dumped their waste in public places or in fixed sites along the streets (Table 3.24). In general, these 'fixed sites' are not delimited or marked in any special way, they have simply developed through use. The survey also indicated that only 16.76% of the urban population have their waste picked up by a garbage collector. The number was less in poor communities, the indication for which was households without toilets, of which scarcely 2.36% have their garbage collected. An earlier study also indicated that only 18% of the urban population were served by the Municipal Solid Waste Management unit (Sharma 1992).

In the absence of adequate waste management services, people have begun to take action in a few communities where the problem is the most severe and where people are aware of the implications of improper waste management. In most places, this is in the form of door-to-door waste collection. KMC's Solid Waste Management Section has a record of 51 groups involved in waste management. Most of these groups serve a few hundred households. According to the survey by Thapa and Devkota (1999), 15.4% of the people in Kathmandu have made their own arrangements for waste removal. Some NGOs are also involved in raising public awareness and providing training on waste management. In the past few years, many children's groups have also been involved in waste management in Kathmandu and Lalitpur. KMC's Children and Environment Programme is working with 12 schools.

(d) Private sector

The private sector is mostly involved in recycling waste. Scavengers and scrap dealers buy or collect scrap materials and sell them to factories in Nepal and India. It is estimated that approximately five

Table 3.24: Methods of household waste disposal

Method of waste disposal	Households with toilets (%)	Households without toilets (%)	All households (%)
Dumping in public places	21.19	24.95	22.10
Dumping in fixed places	28.52	9.64	23.97
Picked up by waste collector	21.33	2.36	16.76
Burying or burning	18.25	13.58	17.12
Composting	8.43	35.32	14.92
Other	2.27	14.14	05.13

Source: CBS (1997)

per cent of Kathmandu's waste materials are recycled in this manner. The amount of recyclable materials that remain in Kathmandu's waste indicates that recycling by the private sector can be increased. This would require separation of waste at source and favourable government policies that encourage recycling (Tuladhar et al. 1998).

The cities of Kathmandu, Bharatpur, and Biratnagar have begun to involve the private sector in waste management. The private sector, together with KMC, is now collecting waste from about 4,000 households in the western part of Kathmandu. Similarly, another company has signed a contract to sweep some of the main streets of Kathmandu. KMC has plans to increase the involvement of the private sector in waste management in the future (Tuladhar 1999).

(e) International conventions and treaties

Table 3.25 provides information on Nepal's obligations to manage the solid waste problem.

Table 3.25: International conventions and treaties on solid waste

Description	Date	Nepal's signature	Main objectives	Major obligations
Convention on the Prevention of Marine Pollution by Dumping of Wastes and Other Matters	29 Dec 1972	1 Jan 1973	Control pollution of the sea	Prohibit dumping or deliberate disposal of waste in the sea
Basel Convention on the Control of Transboundary Movements of Hazardous Wastes	22 Mar 1989	15 Aug 1996	Regulate the transboundary movements of hazardous waste	Define hazardous waste, prohibit and/or regulate the movements of such waste

3.3.5 Conclusion

Rapid and haphazard urbanisation has led to increasing volumes of waste being generated in the urban areas of Nepal. Although the total amount of waste is still small compared to other countries, poor government response and weakness of institutions at the local level have resulted in improper management of the waste. This is causing major problems related to environmental pollution and public health, especially in Kathmandu. The problem is therefore more at the institutional and managerial level than technical. If left unchecked, the waste management problem is expected to become more severe in the future because of the continued increase in the amount of waste generated and in the generation of potentially hazardous waste.

In recent years, some municipalities and communities have started to take effective action such as door-to-door collection, composting, involving the private sector, and mobilising public participation. The challenge is to replicate these efforts on a larger scale and coordinate efforts to solve the growing problem of waste management. More efforts are required to create awareness among city dwellers at the local level about managing solid waste.

(a) Gaps

(i) Policy gap

As mentioned earlier, the Solid Waste Management National Policy and the Ninth Five-Year Plan attempted to promote waste recycling through involving the participation of the private sector and local communities. However, these policies fell short of providing guidelines for implementation and addressing issues such as strengthening of local governments and hazardous waste management.

According to the Local Self-Governance Act, municipalities are responsible for managing waste. However, many municipalities lack the technical knowledge and financial resources for effective waste management. For example, Thimi, a neighbouring municipal town of Kathmandu, has only 17 sweepers and no vehicles to manage the waste generated by almost 40,000 residents. There have been no efforts on the part of the government to address these problems. In fact, even when some municipalities have tried to find solutions on their own, the government has not provided even necessary support. In Kathmandu, over a year ago, the municipality signed a memorandum of understanding with a private company to set up an organic fertiliser plant with a capacity of 300 tonnes/day for recycling its waste and requested the government's assistance in providing 10 ha of land. Instead of helping the municipality, the government called for proposals again and disrupted the process initiated by the municipality. As a result, the waste is not recycled but dumped along the Bagmati River on the instruction of the government. This is a perfect example of how the government has failed to implement its own policies of empowering local governments, involving the private sector in waste management, and maximising recycling. Therefore, there is an urgent need for the government to understand its own policies and start implementing them in a planned manner.

Similarly, many government regulations are also not synchronized with its policies. The scrap tax, which is charged by the District Development Committees (DDC) and the SWMRMC, on materials collected for recycling, is a perfect example. While the policy says recycling should be promoted, the scrap tax is hurting the recycling industry. Instead of abolishing this regressive tax, the government has recently increased the rates on the request of the DDC. The scrap tax needs to be abolished.

The current legislation for waste management, the Solid Waste Management and Resource Mobilisation Act (1987), is obsolete and needs to be changed. A new legislation on waste management, which clearly defines the responsibilities of various organisations, such as municipalities, SWMRMC, MoPE, Ministry of Health, and so on, and states the applicable standards and guidelines for effective waste management practices, should be enacted.

There is also an urgent need to develop policies and legislation related to hazardous waste management. The government should also clarify responsibilities for managing various types of hazardous waste and issue guidelines for their handling, storage, transportation, treatment, and disposal.

(ii) Information gap

Effective management of waste requires information on the amount of waste generated, characteristics of various types of waste, resources allocated for waste management, effectiveness of waste management systems, and impact of waste on human health, the environment, and the economy. This information is lacking. There should be a system for regularly collecting such information and storing it so that it is easily accessible, can be used for analysis for planning and management purposes, and can be disseminated to all stakeholders. At the municipal level, municipalities should be responsible for collecting and managing this information; and at the national level, SWMRMC should be responsible for collecting the information from all the municipalities and regularly monitoring their activities.

(b) Recommendations

- There is an urgent need to prepare plans and programmes to implement the Solid Waste Management National Policy (1993).
- New legislation to replace the Solid Waste (Management and Resource Mobilization) Act (1987) should be enacted.
- The government should define hazardous waste and formulate appropriate policies, legislation, and guidelines for its management.

- The Scrap Tax, which discourages recycling of waste, should be abolished and incentives should be provided for promoting recycling.
- As organic waste is the main type of waste currently not being recycled, production of organic fertiliser from waste should be promoted.
- The capacity of SWMRMC should be strengthened.
- The Ministry of Local Development should provide municipalities with technical and financial assistance for managing their waste.
- As there is a significant gap in the information available on waste management issues, regular waste surveys and analysis of waste management practices in various cities should be conducted by the SWMRMC.

3.3.6 Proposed projects

A cost analysis of some proposed projects related to solid waste management is given below.

Project 1: Development of Policies, Legislation, Standards and Guidelines for Effective Waste Management

Implementing agency:	Ministry of Local Development
Duration:	6 months
Indicative budget:	US$ 100,000
Background:	Although Nepal has a few policies and legislation related to waste management, they need to be updated and new policies and legislation need to be drafted for hazardous waste management. Similarly, the government needs to develop standards and guidelines for use by municipalities and the private sector involved in waste management. This project will be designed to address this need. It will involve a team of international and local experts on waste management policies and legislation working closely with the Ministry of Local Development and municipalities.
Objectives	• Review all existing policies and legislation and recommend changes • Draft new legislation for solid waste management and hazardous waste management • Develop standards and guidelines for solid waste management and hazardous waste management • Provide training to relevant government authorities in policies, legislation, standards, and guidelines related to solid waste and hazardous waste

Project 2: Institutional Strengthening for Waste Management

Implementing agency:	Ministry of Local Development
Duration:	2 years
Indicative budget:	US$ 1 million
Background:	The Solid Waste Management and Resource Mobilisation Centre (SWMRMC) of the Ministry of Local Development is responsible for formulating national policies, legislation, and guidelines and for assisting municipalities to manage their waste. At present, however, the institution is not fully capable of performing its duties. This project is designed to improve the capacity of the SWMRMC, conduct relevant research, and implement a few pilot projects to address some urgently required issues.
Objectives:	• Strengthen the Ministry of Local Development's ability to assist municipalities in managing waste • Conduct research on waste management practices in various municipalities in Nepal. • Develop a system of monitoring the activities of the municipalities and assisting them when necessary • Provide appropriate training to related staff in the Ministry of Local Development and municipalities • Develop projects for improving waste management practices in key municipalities • Implement pilot projects to introduce urgently required activities and to provide experience on project planning, implementation, and evaluation

Project 3: Infrastructural and Equipment Support for Waste Management in Kathmandu Valley

Implementing agencies:	Kathmandu Metropolitan City and other municipalities in the Kathmandu Valley
Duration:	2 years
Indicative budget:	US$ 10 million
Background:	The problem of waste management is most severe in Kathmandu. Although efforts have been made in the past to improve the waste management system in the city, overall the system still lacks adequate infrastructure and equipment. Given the resource constraints faced by most municipalities, it is highly unlikely that municipalities can mobilise enough re-

sources to invest in additional waste management equipment and infrastructure. There is, therefore, a need to support the municipalities in determining their needs, investing in the required infrastructure and equipment, and developing a system of operating and maintaining the equipment. Other municipalities in Nepal can also learn from this experience.

Objectives:

- To assist in establishing facilities, including transfer station, mechanical workshop, recycling facilities, and landfill site for effective waste management in the Kathmandu Valley
- To analyse options in suitable equipment for waste collection, transfer, recycling, and disposal
- To upgrade the equipment currently being used for waste management in Kathmandu
- To develop an effective system for operation and maintenance of waste management equipment

Project 4: Composting

Executive and promoting organisation: Ministry of Agriculture

Implementing organisation: Local NGOs and other firms working in related fields

Duration: At least 5 years

Location: Agricultural districts where agro-forestry and livestock rearing activities are carried out

Cost: The estimated cost is US$ 150 per 10,000 population.

Rationale: Solid waste management is one of the major problems in most of the towns. In Kathmandu Valley, especially, the problem is intensified. Experience indicates that dumping of wastes on the landfill site is not a permanent solution for waste management in Nepal. The alternative solution for waste management is composting. Solid waste generated per person varies from 0.25 to 0.45 kg. About 70% of the total waste composition is organic. Yet, most of the agricultural farmlands lack organic matter. If the waste generated is sorted at the household level, composting will be more cost effective.

Methodology: An awareness campaign about composting organic waste will be carried out at the community level. Each household will be made responsible for primary sorting of organic and other wastes. The collecting time for each locality will be fixed and the time strictly followed. US$ 1.40/family/month will be charged on account for taking away the sorted wastes. Anaerobic composting will take place in public places with the consent of the community. The carbon: nitrogen ratio will be maintained to make high quality bio-fertiliser. The resulting composted waste will be sold at the rate of US$ 0.07/kg. The municipality will invest the initial costs and at a later stage each particular community will run the plant to generate its own income.

References

CBS (1997) *Urban Population Survey – 1996*. Kathmandu: HMGN NPC/CBS

CBS (1999) *A Statistical Year Book of Nepal*. Kathmandu: CBS

Dahal, L. (1985) *A Study on Pesticide Pollution in Nepal*. Kathmandu: IUCN

DoA (2000) *Obsolete, Unwanted and Banned Pesticide Stocks and POPs in Nepal*. Unpublished Revised Inventory Sheet, Plant Protection Directorate, DoA, Kathmandu

GTZ (1988) *Solid Waste Management with People's Participation – An Example in Nepal (SWMRMC)*, Sonderpublication der GTZ, No. 231. Eschborn and Kathmandu: GTZ

Khanal R.K. (1993) *Solid Waste Management in Kathmandu Valley, Nepal*. M.Sc. Thesis. Bangkok: Asian Institute of Technology

Lohani B.; Thanh, N.C. (1978) *Problems and Practices in Solid Waste Management in Asia*. Bangkok: Asian Institute of Technology

Manandhar, M.S., Ranjitkar, N.G.; Pradhan, P.K.; Khanal, N.R. (1987) *Study on Health Hazard in Kathmandu City*. Kathmandu: Nepal National Committee for Man and the Biosphere (MAB)

Manandhar, P.P.; Palikhe, B.R. (1999) *POPs: Current Situation in Nepal*. Paper presented at the Regional Workshop on Management of Persistent Organic Pollutants, 16-19 March, Hanoi, Vietnam

Mishra, S.B.; Kayastha, R.P. (1998) 'Solid Waste Management'. In *A Compendium on Environmental Statistics 1988 Nepal*. Kathmandu: CBS

MLD (1997) *Brief Profile of Municipalities* (in Nepali). Unpublished document, MLD, Kathmandu

MLD (2000) *Municipal Population Estimation*. Unpublished document, MLD, Kathmandu

Mutz, D. (1992) *Compost and Recycling Manual (in Kathmandu).* Kathmandu: SWMRMC

Mutz, D. (1990) 'Technical Choice and Economies of Compost Production'. In Adhikary, B.B.; Spreen, E. (eds), *Solid Waste Management and Resource Mobilization* pp.10-29. Kathmandu: SWMRMC

NPC/IUCN (1992) *Solid Waste Management in Urban Nepal, A Review*. Kathmandu: NPC/IUCN National Conservation Strategy Implementation Project

Pradhan, B. (1998) *Water Quality Assessment of the Bagmati River and its Tributaries, the Kathmandu Valley, Nepal*. Ph.D. Thesis. Vienna: Institute of Water and Wastewater Engineering, BOKU

Rai, Y. (1990) *Statement on the Prospects of Further Vitalising the Waste Recycling Concepts for Nepal*. Report on the Recycling of Waste in Nepal Workshop. Kathmandu: SWMRMC

Rajbhandari, R.A. (2000) *Health Hazard For Municipal Waste Workers: A Case Study Of Sawal Bahal Kathmandu, Nepal*, M.Sc. Thesis. Bangkok: Asian Institute of Technology

RESTUC (1999) *A Study of Solid Waste and its Management in Kathmandu*. Kathmandu: WHO

Sharma, M.S. (1987) 'Energy Pricing Issues in Nepal'. In Kumar, M.S. (ed) *Energy Pricing Policies in Developing Countries*, pp103-133. Bangkok: ESCAP

Sharma, P. (1992) *Urbanization and Sustainable Development, Nepal Economic Policies for Sustainable Development*. Manila: ADB, Kathmandu: ICIMOD

Sharma P. (1989) *Urbanization in Nepal*, Papers of the East-West Population Institute. No. 110. Honolulu: East-West Center

Tabasaran, I.O. (1976) *Expert's Opinion on the Reorganisation of Solid Waste Disposal in Kathmandu Valley Especially in the Cities of Kathmandu, Patan and Bhaktapur*. Stuttgart: GTZ

Thapa, G.B.; Devkota, S.R. (1999) *Managing Solid Waste in Metro Kathmandu*. Studies in Regional Environmental Planning, ACRD Monograph 1, School of Environment Resources and Development. Bangkok: Asian Institute of Technology

Tuladhar, B. (1996) 'Kathmandu's Garbage, Simple Solutions Going to Waste'. In *Studies in Nepal History Society*, 1 (2)

Tuladhar, B. (1999) *Private Sector Participation in Kathmandu's Solid Waste Management, A Status Report*. Kathmandu: KMC

Tuladhar, B. (1999a) *Hazardous Waste Management Nepal Country Report.* Kathmandu: WHO

Tuladhar, B.; Ban, A. (1997) *Technical and Economic Analysis of Bhaktapur Compost Plant*. Gouda (Netherlands): Urban Waste Expertise Program, WASTE Consult

Tuladhar B., Van den Berg, S.R.; Ban, A. (1998) *Assessment of Waste Recycling Technologies in Nepal.* Kathmandu: National Council for Science and Technology

3.4 Water Quality

3.4.1 Introduction

Water is Nepal's largest known natural resource. The major sources of water are rainfall, glaciers, rivers, and groundwater. Of these, rivers are the most important running surface water in terms of water volume and potential development. There are over 6,000 rivers in Nepal with an estimated total length of more than 45,000 km (CBS 1995). These rivers flow through the high mountains in the country and thus have turbulent and rapid flow and considerable self cleansing abilities through mechanical and oxidation processes. All large rivers are fed by snowmelt from the Himalayas, and hence they are perennial. The country has 660 lakes with stagnant surface water of more than one hectare in area. Mean annual rainfall is about 1,700 mm, 75% of which occurs during the monsoon season from June through September. The average annual renewable water volume of the country is about 224 billion m^3 (Yogacharya 1998).

Over time, the country's requirements for water for drinking and personal hygiene, agriculture, religious activities, industrial production, hydropower generation, and recreational activities such as navigating, rafting, swimming, and fishing have increased. Yet, the rivers are also the main repository for the nation's untreated sewage, solid waste, and industrial effluent.

Concerns about water include both quantity and quality of the resource and relate to human health standards. Normally, a person requires 2.5 litres of water per day for their basic physiological processes (Tebbutt 1992). In addition, water is also required for domestic hygiene such as washing, bathing, cleaning, and so on. An adequate supply of drinking water alone does not fulfil human health needs, as its quality is equally important. Water quality refers to the suitability of the water to sustain living organisms and other uses such as drinking, bathing, washing, irrigation, and industry. Changes in water quality are reflected in its physical, biological, and chemical conditions; and these in turn are influenced by physical and anthropogenic activities (Plates 16 and 17).

Plate 16: Polluted water in the holy River Bagmati near Pashupati temple, the most sacred site in Kathmandu (M. Khadka)

Plate 17: The Bagmati River is polluted by effluents from a carpet factory located on its bank *(S. Shakya)*

3.4.2 Pressure

There is intense pressure on the water resources being used in Nepal due to the limited amount available with respect to demand. Over the last few decades, the population in the country has grown rapidly at over two per cent per annum. Urbanisation caused by natural growth and migration is another factor that puts pressure on the existing water supply in urban areas. Other activities that need water are industries, irrigation, motor workshops, and so on. Natural factors, such as landslides and floods, also put pressure on water resources by damaging reservoirs and irrigation canals. All these activities affect the quality of water.

(a) Surface water

There is a big demand for surface water because of the rapidly increasing population. The annual drinking water supply is inadequate to meet the growing demand. Similarly, the use of water for agriculture is increasing. Table 3.26 shows that in 1998 the total annual withdrawal was 7.4% of the total available. In 1994, it was 5.8%. The relative share of agriculture in total water withdrawal is excessively high, with a trend towards an increasing share of total water withdrawal.

Table 3.26: Surface water availability and its use in Nepal

	1994	1995	1996	1997	1998
Total annual renewable surface water (km^3/yr)*	224	224	224	224	224
Per capita renewable surface water ('000 m^3/yr)	11.20	11.00	10.60	10.50	10.30
Total annual withdrawal (km^3/yr)	12.95	13.97	15.10	16.00	16.70
Per capita annual withdrawal ('000m^3/yr)	0.65	0.69	0.71	0.75	0.76
Sectoral withdrawal as % of total water withdrawal					
domestic	3.97	3.83	3.68	3.50	3.43
industry	0.34	0.31	0.30	0.28	0.27
agriculture	95.68	95.86	96.02	96.22	96.30

Source: WECS (1999); Yogacharya (1996, 1998); Bhusal (1999)
* including catchments outside Nepal

The pressure on drinking water supply is very heavy, particularly in the Kathmandu Valley. Almost all major rivers have been tapped at source for drinking water supplies; and the supply is only about 115 million l/day (mld) during the rainy season, 79% of the estimated daily demand of 145 mld (NPC 1998). Of the total drinking water supply, the carpet industries alone consumed about 6.1 mld of water and generated 5.5 mld of waste water (MOWR 1999).

Despite having 83,000 megawatts capacity for hydropower generation, only 252 megawatts are generated in Nepal, i.e., 0.3% of the total potential (NEA 1999). The demand for electricity has increased tremendously. During the last 15 years, electricity consumption increased from 313 in 1984 to 1,112.8 GWh in 1998. The per capita share of electricity is about 50 kWh per annum. The domestic sector, which includes the commercial and non-commercial sectors, uses the highest quantity of the electricity generated (Figure 2.1).

(b) Groundwater

The country's groundwater is being used for domestic, industrial, and irrigation purposes. It is estimated that the Terai region has a potential of about 12 billion m^3 of groundwater, with an estimate annual recharge of 5.8 to 9.6 billion m^3 (the maximum that may be extracted annually without any adverse effects) (WECS 1999). Current groundwater withdrawal is about 0.52 billion m^3 per year. The aquifers in this region, which consist of sediments of alluvial origin, are very favourable for water accumulation beneath the surface area. The Bhabar zone, which is an area contiguous with the Terai, as well as having better forest coverage, is the main recharge area for the latter. Groundwater is the best alternative source of water supply in the Terai region. Therefore, the forest in the Bhabar zone needs to be conserved, at least in its present condition, to ensure the present level of groundwater.

The groundwater of the Kathmandu Valley is under immense pressure as it is being heavily used for drinking as well as for other activities that require water, resulting in a decline of its water level. The study of Metcalf and Eddy (2000) depicts an alarming situation concerning a drop in pumping water level from 9m to as much as 68m in the valley over a few years (Table 3.27). However, because there is no regular monitoring programme, groundwater depletion rate is uncertain in the Kathmandu Valley. Unfortunately the recharge areas in the surrounding hills, which were once densely forested, have been turned into agricultural land so that there is little support from the surrounding watershed areas to replenish the groundwater in the valley. The total sustainable withdrawal of groundwater from the valley's aquifers is approximately 26.3 mld (Stanley 1994), but the total groundwater currently extracted is about 58.6 mld (Metcalf 2000). The studies indicate that the groundwater in the valley is overexploited. Since studies are not carried out on a regular basis, it is difficult to determine the real degree of overexploitation.

Table 3.27: Deep aquifer depletion at selected locations during the dry season, Kathmandu Valley

Location	Previous water level (m)			1999 Water level (m)		Decline	
	Base year	SWL	PWL	SWL	PWL	SWL	PWL
Bansbari	1997	48.08	67.60	80.63	136.14	32.55	68.54
Baluwatar	1976	FW	21.00	22.41	30.00	22.41	9.00
Pharping	1976	FW	25.00	13.00	44.00	13.00	19.00

Source: Metcalf and Eddy (2000); CEMAT (2000)
PWL = pumping water level SWL = static water level, FW = flowing well

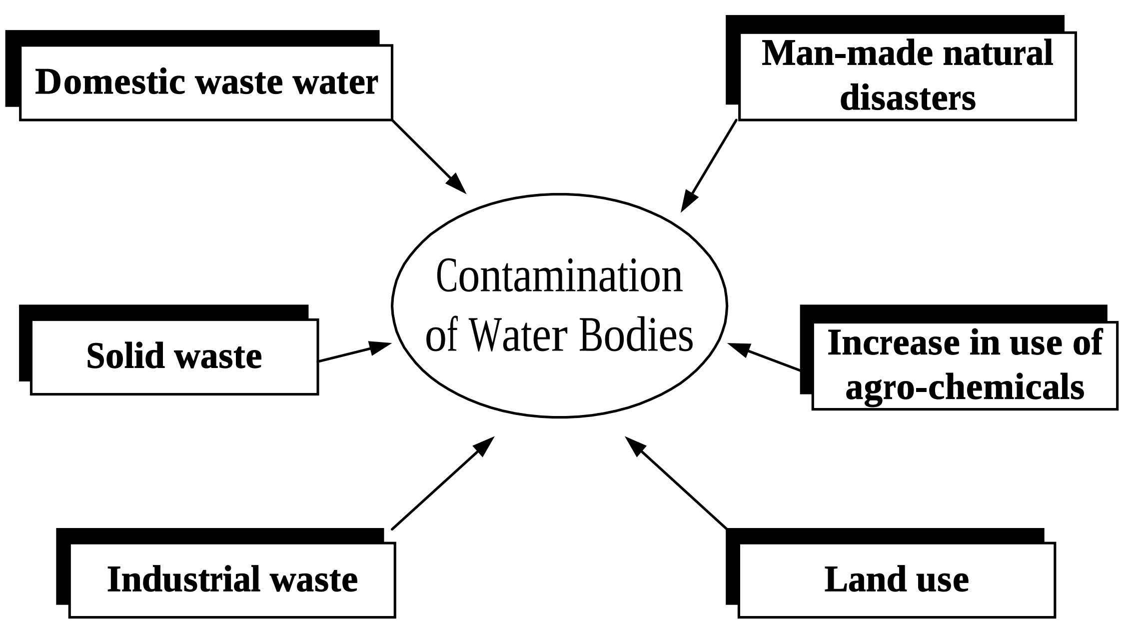
(c) Water quality

The rising demand for water by the population has put pressure on the quality of water. The quality of water sources at both surface and groundwater levels is degraded. The schematic representation in Figure 3.17 summarises the factors affecting water quality.

(i) Domestic Waste

Domestic waste includes both grey and black water. Few houses are connected to a waste water system. Many people, even in urban areas, defecate on open ground, often along the banks of rivers and streams. There is no sewerage network system in the country's rural region or any of the municipal

Figure 3.17: Factors leading to deterioration in water quality



areas apart from the Kathmandu Valley towns. Even in the Valley towns, only 15% of the houses have access to a sewerage facility (NWSC 1999). Increasingly, pit latrines are being introduced, particularly in county areas, and some people have septic tanks. Even so, much domestic waste water percolates directly into the groundwater or flows as runoff into local streams. Likewise, all domestic sewers discharge directly into rivers without treatment. Analysis of domestic waste, based on Tebbutt (1992), shows that if an average of 50g biological oxygen demand (BOD)/person/day is produced in the Kathmandu Valley, it will produce 50,000 kg BOD/day from the one million inhabitants. An average of 20,846 kg BOD/day has been recorded for the Bagmati River at the outlet, constituting 42% of the total BOD load produced by the valley's people (CEMAT 2000). The waste water generated per person is estimated on the basis of per person per day water use, which is about 60 l for the urban area (NPC 1997). About 85 % of the total water used ends up as domestic waste water. The estimated volume of waste water generated by each municipality is depicted in Map 3.8.

(ii) Industrial waste

Industries causing water pollution constituted 40% of the total 4,271 industrial establishments recorded in the country in 1991/92. The number of officially recorded industrial establishments (with more than ten employees) between 1981 and 1996 is shown in Table 3.28. It is not known whether the drop in 1996 reflects a real decrease, or a change in data collecting methods, or even willingness by businesses to register.

Table 3.28: Number of industrial establishments or plants (with ≥10 employees)

Census year	Number of factories/plants
1981	971
1986	2054
1991	4271
1994	4487
1996	3557

Source: CBS (1998)

Table 3.29 shows that the Kathmandu Valley hosts more than 72% of the country's water-polluting industries. Many of these industries discharge effluents into local rivers without treatment, spoiling the quality of river water. The study of Devkota and Neupane (1994) indicates that the contribution of industrial effluents to the rivers is about seven per cent of the total effluents (domestic and industrial) in the Kathmandu Valley.

Table 3.29: Water polluting industries compared to total industrial units (1992)

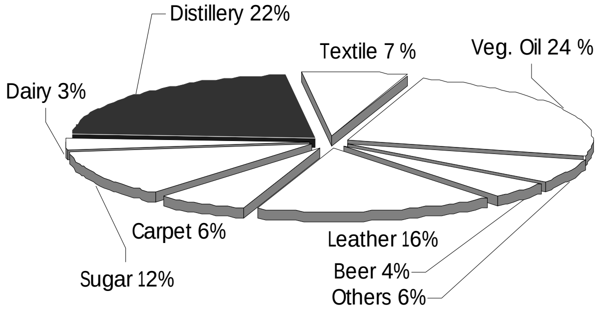
Location	Country total	Kath-mandu Valley	% of total units in the Valley
Total industrial units	4,271	2,174	50.9
Water-polluting industrial units	1,714	1,241	72.4

Source: Devkota and Neupane (1994)

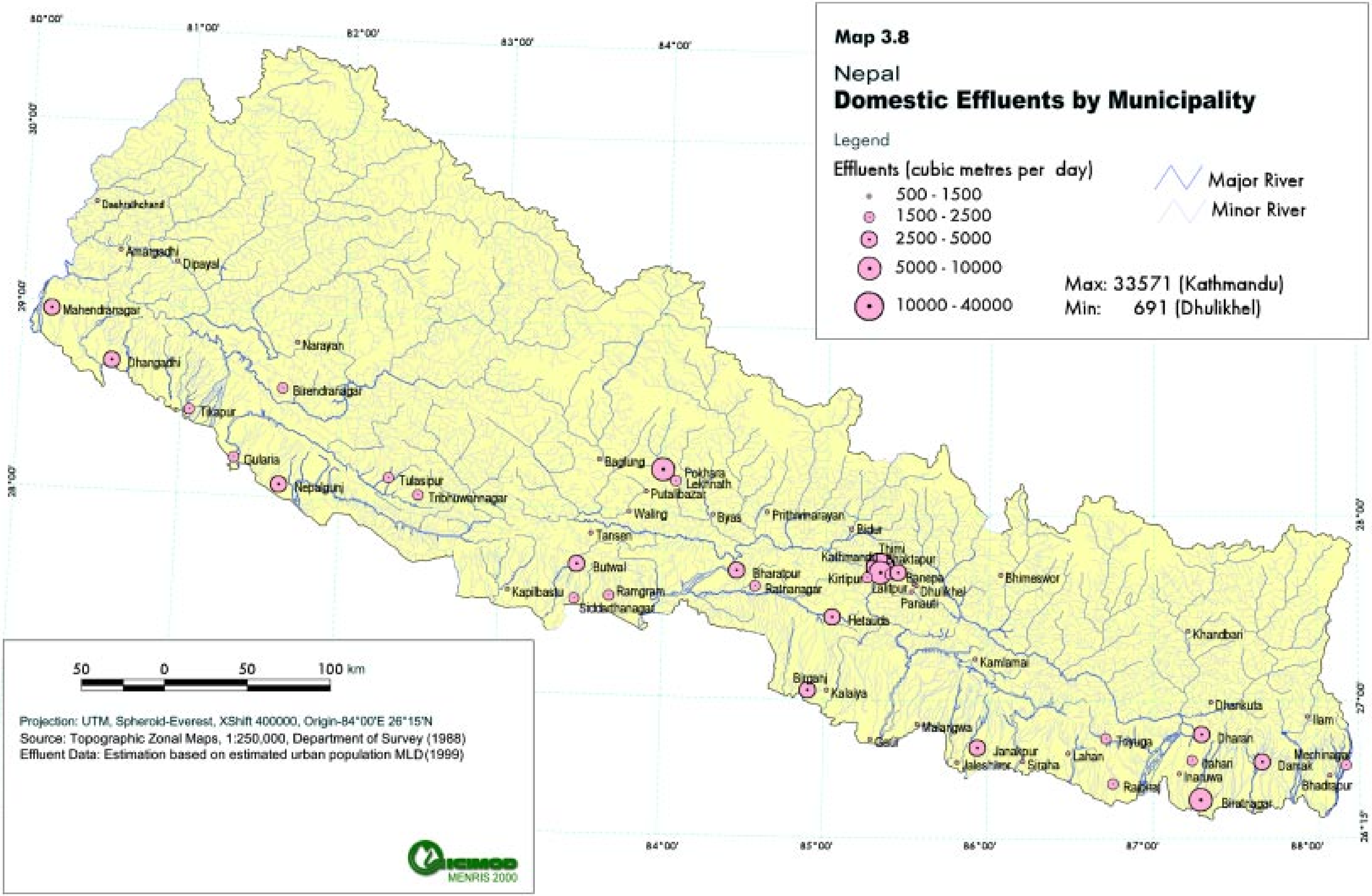
Ten years ago a total of 125 industrial plants throughout the country were identified as industrial pollution 'hot spots' (IUCN 1991). Sixty plants were identified as highly polluting hot spots. These included brewery and distillery, cement, cigarette and tobacco, feed, iron and steel, rosin and turpentine, soap and chemical solvent, oil and vegetable ghee, jute, 'kattha' (*Acacia catechu*), leather and tannin, marble and magnetite, quarry, paper and pulp, sugar and 'khandsari' (raw sugar paste), and textile industries.

Industrial pollution by industries has been measured in terms of waste water volume, biological oxygen demand (BOD), and total suspended solid (TSS) loads of the effluents. In terms of relative contribution of BOD load, the major polluting industries are the vegetable oil, distillery, and leather industries (Figure 3.18).

Figure 3.18: Major industrial sectors responsible for BOD load in Nepal (Total BOD 5,741 tonnes)



Source: Devkota and Neupane (1994)


Map 3.8
Nepal
Domestic Effluents by Municipality
Legend
Effluents (cubic metres per day)
500 - 1500
1500 - 2500
2500 - 5000
5000 - 10000
10000 - 40000
Major River
Minor River
Max: 33571 (Kathmandu)
Min: 691 (Dhulikhel)
50 0 50 100 km
Projection: UTM, Spheroid-Everest, XShift 400000, Origin-84°00'E 26°15'N
Source: Topographic Zonal Maps, 1:250,000, Department of Survey (1988)
Effluent Data: Estimation based on estimated urban population MLD(1999)
ICIMOD
MENRIS 2000
Mahendranagar
Dhangadhi
Tikapur
Gularia
Nepalgunj
Birendranagar
Narayan
Amargadhi
Dipayal
Tulasipur
Tribhuwannagar
Baglung
Pokhara
Lekhnath
Putalibazar
Waling
Tansen
Butwal
Kapilbastu
Siddharthanagar
Ramgram
Byas
Prithvinarayan
Bharatpur
Ratnanagar
Bidur
Kathmandu
Thimi
Bhaktapur
Kirtipur
Lalitpur
Banepa
Dhulikhel
Panauti
Hetauda
Birganj
Kalaiya
Bhimeswor
Kamlamai
Khandbari
Dhankuta
Ilam
Malangwa
Gaur
Janakpur
Jaleshwor
Siraha
Lahan
Triyuga
Rajbiraj
Dharan
Itahari
Inaruwa
Biratnagar
Damak
Mechinagar
Bhadrapur

Box 3.3: Carpet industry pollutes river

The carpet industries of the Kathmandu Valley have generated waste water containing contaminants such as dirt, fibres, residual dyes, and other chemicals which contributed 74% of the total industrial effluents, 31% of the industrial BOD load, and 53% of the industrial TSS load.

(iii) Man-made natural disasters

In most parts of the country's hill region, the conditions of watersheds and gullies are deteriorating as a result of deforestation and cultivation of sloping areas. As a result, landslides and soil erosion occur quite often at varying magnitudes, and these directly affect the quality of surface water. The annually increasing turbidity of the Rapti River, for instance, may be due to land degradation in its watershed area (Table 3.30).

Table 3.30: Water quality of the Rapti River at Pidnighat, central Terai, Nepal

Constituents	1995	1996	1997	1998
Turbidity, NTU	15	67	64	116
Ammonia, μg/l-N	110	225	370	125
Nitrate, μg/l-N	125	60	40	20
Nitrite, μg/l -N	2	16	3	4
Phosphate, μg/l-P	147	136	130	30

Source: CEMAT (1999)
NTU = nephelometer turbidity unit

(iv) Increase in the use of agro-chemicals

The agricultural system in Nepal has been intensified in some areas by increasing use of chemical fertilisers and pesticides (Plate 18). The average use of chemical fertilisers, such as nitrogen, phosphorus, and potassium (NPK), per hectare has increased tremendously in the country from 7.6 kg in 1975 to 26.6 in 1998. In the agriculturally prosperous area of eastern Chitwan district, the use of fertilisers is estimated to be 420 kg/ha. However, the present level of use is still the lowest in South Asia (Basnyat 1999). The average nutrient level recorded in one of the rivers of the Central Terai is seen to fluctuate, as shown in Table 3.30. However, the concentration of nutrients is within the permissible level for river water quality.

Plate 18: Intensive, cultivated fields contribute chemical fertilisers to the Kodku River polluting its water, which at the same time is being used by local people for washing clothes and bathing *(B. Pradhan)*

Altogether 250 types of pesticides are used in Nepal. The average use of pesticide was 0.17 kg/ha in 1986 (CBS 1998) and 0.142 kg/ha in 1995 (Palikhe 1999). All these pesticides are organochlorides and organophosphates. Organochlorides are persistent organic pesticides, which pass through the food chain through the processes of bioaccumulation and biomagnification, and thus are hazardous to health. Organochloride pesticides in the range of 34–100 ppb were detected in samples of fish flesh and plankton in three lakes, viz., Begnas, Phewa, and Rupa, in the Pokhara Valley, west Nepal (Palikhe 1999).

(v) Change in land-use pattern
Nepal has witnessed a dramatic change in land-use pattern over the last few decades as a result of the rapid growth in and migration of population. The forest area is declining, while agricultural land is being extended to sloping and/or degraded areas of land, as well as forest lands (although such instances are not obvious from the data). Likewise, the area covered by urban settlements, roads, and other activities is on the increase. Agricultural land increased from 1,592,000 ha in 1975 to 2,968,000 ha in 1985 and remained constant till 1999 (MoA 1998), whereas the forest area declined from 5,617,000 ha in 1978/79 to 4,269, 000 ha in 1994 (DFRS 1999). The decline in forest area has affected not only the water recharge capacity of groundwater sources, but it has also aggravated landslides, soil erosion, and floods. The latter are responsible for increasing the turbidity of surface water.

The land-use pattern in most of the settlements in Nepal has changed. There are indications that the urban area of the Kathmandu Valley increased from 26% in 1978 to 46.2% in 1996. Likewise, the rural built-up area also increased from 11.2% to 24% during the same interval (Pradhan 2000). As a result, the groundwater recharge area has decreased, affecting both quality and quantity of groundwater sources. The forest area of the valley's surrounding watersheds decreased by 40% from 1955-1996, and this has seriously affected the recharge capacity of groundwater sources.

3.4.3 State

The total available surface and groundwater potential of the country is 224 billion m^3 and 12 billion m^3 respectively (WECS 1999). Figure 3.19 depicts the schematic surface water balance for Nepal. The total water demand for various purposes, such as domestic, industry, and commerce, was estimated to be 1,239.7 million mld in 1998. It is expected that all people living in both rural and urban areas will have access to drinking water by 2008 (Table 3.31).

The water quality of selected rivers across the country, as shown in Table 3.32, is at an acceptable standard. The satisfactory level may be due to their high discharge rate and limited human interference. As a result, pollutants are easily diluted and assimilated.

Like the major urban rivers (see below), the water quality of the lakes in the only lake valley, Pokhara, is polluted. Of the four lakes shown in Table 3.33, Phewa, Begnas,

Table 3.31: Population (million) forecast for access to drinking water for the period 1998–2008

Year	Rural population (millions)		Urban population (millions)		Total population (millions)		
	Total	Benefit	Total	Benefit	Total	Benefit	%
1998	18.8	11.3	3.2	1.9	22	13.2	60
2003	20.4	17.5	3.6	3.1	24	20.6	86
2008	21.8	21.8	4.2	4.2	26	26	100

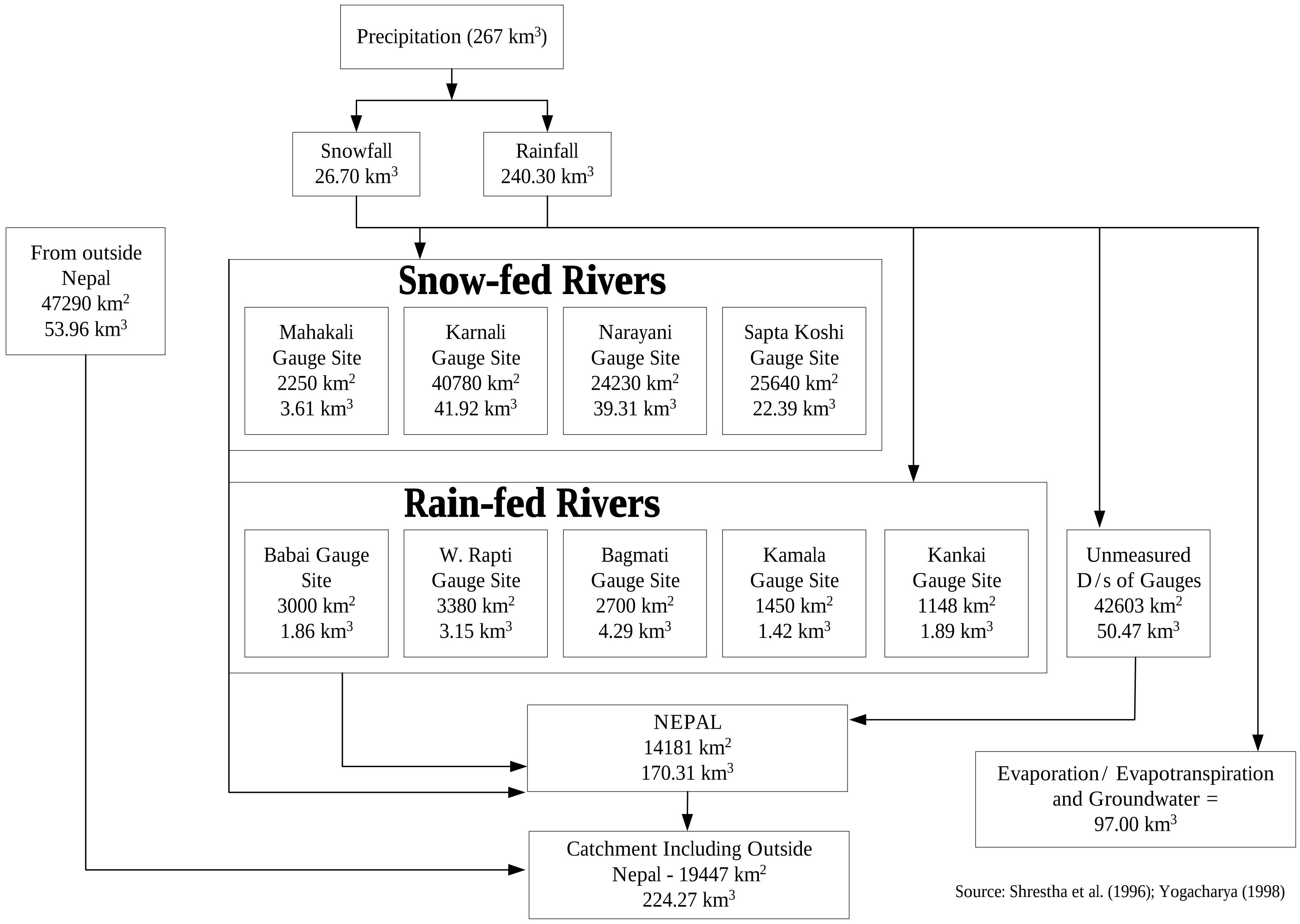
Source: CBS (1998)

Table 3.32: Water quality of major rivers during the dry season in various regions of Nepal

Location of Rivers	pH	TDS (mg/l)	DO (mg/l)	BODs (mg/l)
Mahakali at Pancheswar, Far West	8.8	110	5.0	2.0
Karnali at Chisapani, Far West	8.9	264	10.5	1.5
Bheri at Chatgaon, Mid West	7.8	208	9.3	1.1
Seti at Ramghat, West	8.2	222	9.3	2.0
Rapti at Sauraha, Central	7.8	213	8.7	2.5
Arun, East	6.5	200	9.1	2.1
Kankai, East	7.7	60	8.7	2.0
Mechi, East	8.3	30	8.9	1.8

Source: CBS (1998); DHM (1999)
DO = dissolved oxygen, BOD = biological oxygen demand,
TDS = total dissolved solids

Figure 3.19: Schematic water balance of Nepal in billion cubic metres (km^3)



Source: Shrestha et al. (1996); Yogacharya (1998) and Rupa, in the Pokhara Valley have a high level of nutrients (eutrophic condition), indicating poor quality water. Gosainkund, which is located in the remote area north of the Kathmandu Valley, shows better quality of water because there is less human interference.

Table 3.33: Water quality condition of selected lakes, Nepal

Parameters	Phewa	Begnas	Rupa	Gosainkund
BOD, mg/l	2.0	2.0	2.68	NK
$N\text{-}NO_3$, mg/l	0.12	0.1	0.1	0.2
TN, µg/l	260	233.6	176.4	210.0
TP, µg/l	45.0	43.5	59.6	8.6
$P\text{-}PO_4$, µg/l	30.0	18.7	23.3	3
Chlorophyll a, µg/l	8.0	5.5	6.5	1.2
E.coli/100 ml	8.0	28.9	393.3	NK

Source: ENPHO (1995, 1998a); COSMOS (2000)
NK = Not known

(a) Urban water

In Nepal, the urban population is growing and both the percentage of population being served by drinking water connections and the total connections have increased. However, the remarkable point is that the consumption per capita or per connection has decreased (Table 3.34). With the increase in population, the total water demand per year has also increased. Nevertheless, the per capita consumption (of piped water has decreased because of scarcity of water. This has put pressure on groundwater extraction, especially in the Kathmandu Valley. Another striking feature of the drinking water supply system in the urban towns of Nepal is unaccounted for water or 'leakage', which accounts for 40% of the total supply. Water supply seems to be one of the most crucial problems in the country.

Table 3.34: Water supply and coverage in urban areas of Nepal

Particulars	Before 1992		End of 1998	
	Kathmandu Valley towns	Towns outside the Valley	Kathmandu Valley towns	Towns outside the Valley
Population ('000)	780	640	1097	878
Population served (%)	68	56	87	57
Total produced (mld)	87	55	107	63
Total surface water produced (mld)	61	26	78	36
Total groundwater produced (mld)	26	29	29	27
Water sold (mld)	52	33	64	38
Unaccounted water (%)	40	40	40	40
Per capita consumption (lcd)	98	92	67	76
Consumption per connection (lcd)	674	927	636	721
Total connections	77468	35588	100916	52379

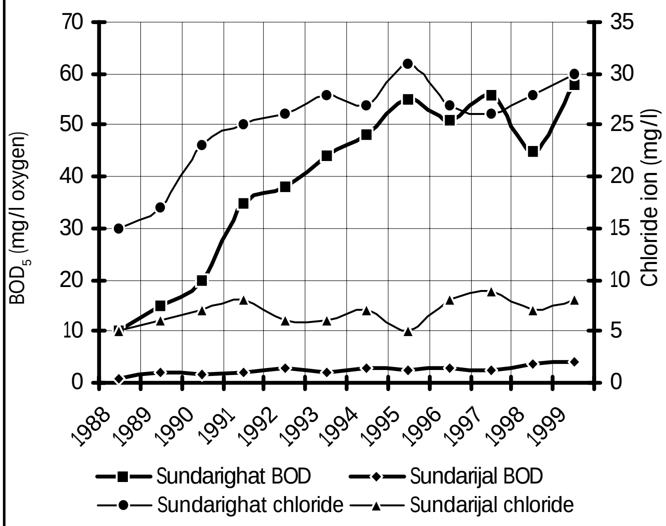
Source: Nepal Water Supply Corporation (1999)
lcd = litre consumption /day; mld = million litre/day

The issue of water pollution in the urban areas of Nepal is related to the municipal sewerage system and storm-water drainage. The municipal sewerage system is directly related to the river environment since the untreated sewage is discharged directly into the rivers. After the formation of the Town Development Fund Board (TDFB) in 1987, several municipalities begin to construct storm drains with the Board's financial assistance (MoPE/HMG 1998). In Kathmandu Valley, the storm-water drainage system has been mixed with the sewerage system. This is mainly because the sewers are connected to the storm drains.

The quality of water in urban rivers is decreasing CEMAT (1999); ENPHO (1996a); GEOCE 1999; MoPE (2000); NEC/SEC (1999); NESS (1995); Pradhan (1998). The Bagmati River in the

Kathmandu Valley is an example (Figure 3.20). Two pollution indicating parameters, BOD_5 and chloride (Cl^-), were measured at two points on the Bagmati River: Sundarijal at the headwater in the north and Sundarighat on the city outskirts in the south-west (ENPHO 1996a;1996b, Pradhan 1998; CEMAT 1999). The quality of the river water is very poor at Sundarighat, as indicated by its higher BOD_5 and chloride ion values. This site has also shown an increasing trend in concentration of these parameters, while the Sundarijal site has shown little marked change in the concentration of parameters. The trends of the parameters clearly indicate that the Sundarighat site is more affected by anthropogenic factors than the Sundarijal site. Map 3.9 shows that the quality of the Bagmati River and its tributaries is very poor in the city centre and improves beyond the valley at the south-west point (Pradhan 1998; CEMAT 1999) where additional freshwater streams mix with the main river.

Figure 3.20: BOD and Cl^- trend at two sites of the Bagmati river



Source: ENPHO (1996), Pradhan (1998), CEMAT (2000)

(b) Aquatic Biodiversity

The rivers of Nepal flow through diverse geographic environments and thus possess a variety of species of aquatic macro-invertebrates. Most of them are pollution indicators and therefore they can be used to determine the river water quality. As the quality of the water body changes, the aquatic animals (macro-invertebrates) in that particular area will also change. They are either washed away or die depending upon their sensitivity to pollution.

Table 3.35: Aquatic animals (macro-invertebrates) of Nepal

Group of Aquatic Animals	Total number of species	
	Kathmandu Valley*	Nepal**
Coleoptera	15	181
Diptera	55	202
Ephemeroptera	33	29
Megaloptera	1	NK
Odonate	5	202
Oligochaeta	5	NK
Trichoptera	14	59
Gastropoda	7	NK
Heteroptera	7	NK
Plecoptera	9	67
Hirudinia	2	NK

Source:*Pradhan (1998); **Sharma (1998)
NK = Not known

There are very few detailed studies on characteristic features of the aquatic insects of Nepal. No information is available on how many of the total aquatic animals are threatened or extinct. Some aquatic macro-invertebrates of the Kathmandu Valley and the country as a whole are listed in Table 3.35. The study of the Valley rivers shows that the Bagmati River and its tributaries are rich in aquatic biodiversity, particularly in the headwater region, and become poor because of organic pollution as they flow through the core city area.

(c) Groundwater quality

Groundwater is the main source of drinking water in Nepal's Terai region. However, concentrations of iron and manganese in the groundwater are on the whole above World Health Organisation (WHO) standards (Table 3.36). As shown in the table, a water quality analysis for seven sites indicated that water is contaminated (not free from coliform bacteria) at all but two sites. People consume water ignoring its quality.

Box 3.4: Paper mills pollute the Narayani and the Orahi rivers

Two paper mills - Bhrikuti and Everest, are located on the banks of the Narayani and Orahi rivers, respectively. The Bhrikuti Paper Mill lies in the Chitwan valley and the Everest Paper Mill is in Mahendranagar in the Far West. The effluent from the former is discharged directly into the Narayani River. The effluent flows barely 500 metres from the mill. The river has endangered species such as dolphin, gharial, and mugger and flows through the Royal Chitwan National Park, which is listed as a world heritage site. The effluent of the Everest Paper Mill is collected first in a nearby pond and then discharged into the Orahi River, 300 metres away from the mill. However, the discharge rate from the two rivers is quite varied. The average discharge rates for the Bhrikuti and Everest mills were 0.25 m^3/s and 0.112 m^3/s respectively. While the BOD values upstream of both rivers - Narayani and Orahi - were 1.5 and 1.6, downstream they were 10 and 70.2 respectively (Pradhanang et al. 1988). Because of the greater dilution effect, the impact of discharge on local river ecology is less in the former than in the latter.

Source: IUCN (1991)

Table 3.36: Water quality of shallow groundwater aquifers in the Terai region (1990)

Sites (District)	Chloride (mg/l)	Ammonia-N (mg/l)	Nitrate-N (mg/l)	Iron (mg/l)	Manganese (mg/l)	Coliform (cfu/100ml)
Panchgacachi (Jhapa)	15.4	0.70	0.2	6.0	0.8	11.1
Baijnathpur (Morang)	16.4	0.50	0.2	4.5	0.5	15.9
Bayarban (Morang)	17.6	0.50	2.4	6.0	0.6	0.0
Takuwa (Morang)	21.0	1.00	1.0	10.4	0.4	45.9
Shreepur Jabdi (Sunsari)	37.2	0.90	0.2	8.0	0.6	25.5
Bandipur (Siraha)	195.6	0.70	3.5	0.4	0.4	0.0
Naktiraipur (Saptari)	54.5	1.20	0.3	12.0	1.3	16.0
WHO standard	250.0	1.24	10	3.0	0.5	nil

Source: ENPHO (1990)

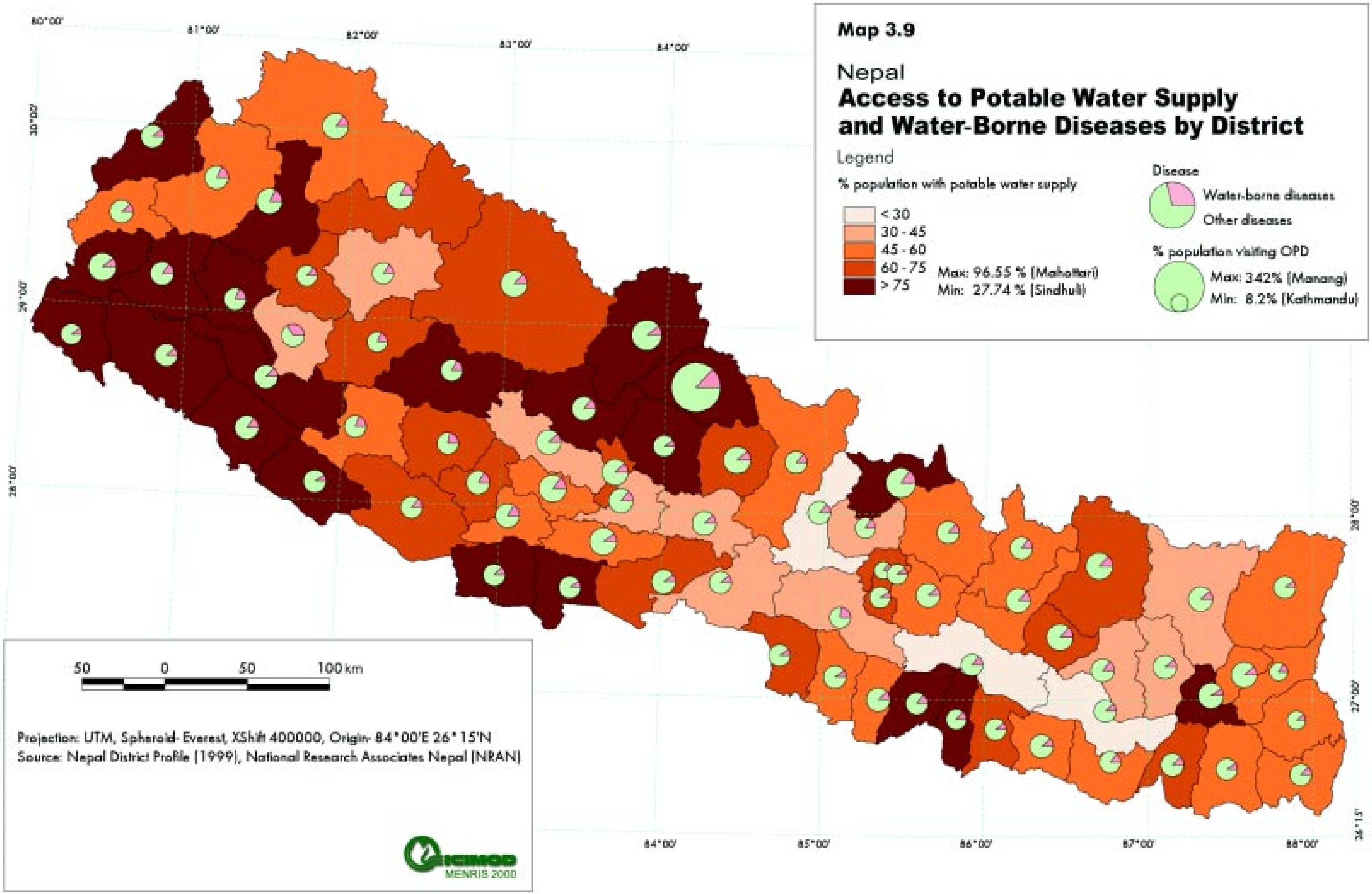
The groundwater quality in the Kathmandu Valley is also contaminated due to polluted surface water, leachate, and sewage. None of the water from groundwater sources, such as dug-wells, deep tubewells, stone spouts, ponds, and piped water in the valley, as given in Table 3.37, is guaranteed free from faecal contamination (ENPHO 1999; NWSC 1999). The studies of ENPHO (2000), CEMAT (1999), and Jha et al. (1997) indicate that the concentration of ammonia-N even in deep wells is above WHO standards. Similarly, nitrate-N concentration is also higher in shallow and dug wells than the WHO standard.

Table 3.37: Bacteriological water quality from different sources, Kathmandu Valley

Faecal coliform /100 ml	Value as % of sample units of 15							WHO guideline value
	Dug well	Shallow well	Deep well	Spring	Stone spout	Pond	Piped water*	
0	0	60	80	40	20	0	60	0
1-100	40	30	15	30	40	0	20	-
101-1000	30	5	5	30	40	0	20	-
>1000	30	5	0	0	0	100	0	-

Source: ENPHO (1999)
* NWSC (1999)

Map 3.9



Projection: UTM, Spheroid- Everest, XShift 400000, Origin- 84°00'E 26°15'N
Source: Nepal District Profile (1999), National Research Associates Nepal (NRAN)

ICIMOD MENRIS 2000

3.4.4 Impacts

Water pollution is the most serious public health issue in Nepal. There is a vital connection between water and health. The rivers are the main places for disposal of urban solid waste, domestic effluents, and industrial effluents, which are responsible for polluting the water and causing water-borne diseases. Yet, government policy has given little emphasis to this issue (UNICEF 1987).

(a) Water quality and water related diseases

Despite the poor quality of water supplied, treatment of water is given very little priority throughout the country except in the Kathmandu Valley where water supplies are treated with disinfectant chlorine. Table 3.38 shows that the percentage of treatment in the total water supply is very low. In the Kathmandu Valley's urban areas, the percentage of treated water in the total water supply was over 80% in 1998 (NWSC 1999). However, the residual chlorine level in the drinking water of the majority of water samples in the valley is lower than the WHO standard (0.2 mg/l) (ENPHO 2000). This means the treatment of drinking water is not effective.

Table 3.38: Water supply and treatment capacity

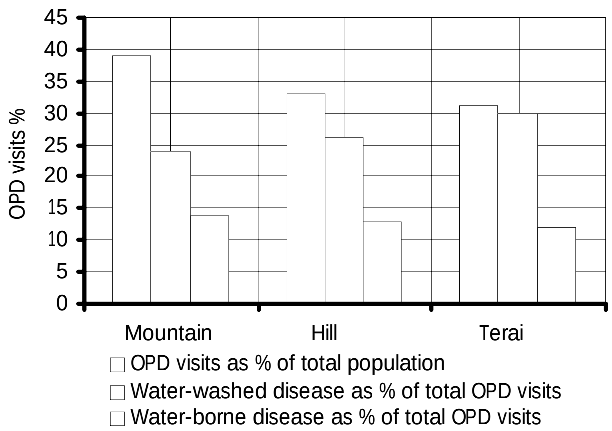
Water condition	**Year**		
	1992	**1995**	**1998**
Total water supply (mld)	142	151	170
Total water treatment capacity (mld)	35.3 (24.8%)	83.9 (55.5 %)	87.9 (51.7%)

Source: NWSC (1999)

Per capita water consumption in Nepal is also low compared to that of other developing countries. This means that both quality and quantity of drinking water in the country are substandard, and this is responsible for causing different types of water-washed and water-borne diseases* (Plate 19). Diseases caused by contaminated water are among the ten most prevalent diseases in Nepal (DoHS 1998). Figure 3.21 shows the percentage of total outpatient department (OPD) visits as a percentage of the population and the proportion of these related to water-borne and water-washed disease. The Terai region has the largest percentage of total OPD visits related to water-washed disease. Diarrhoea, which is caused by poor sanitation, hygiene, and water quality, is one of the most prevalent water-borne diseases in Nepal. During 1995/96, the

Plate 19: Use of polluted water from the Bagmati River in Kathmandu Valley for bathing *(M. Khadka)*

Figure 3.21: Water-related disease, Nepal (1998)



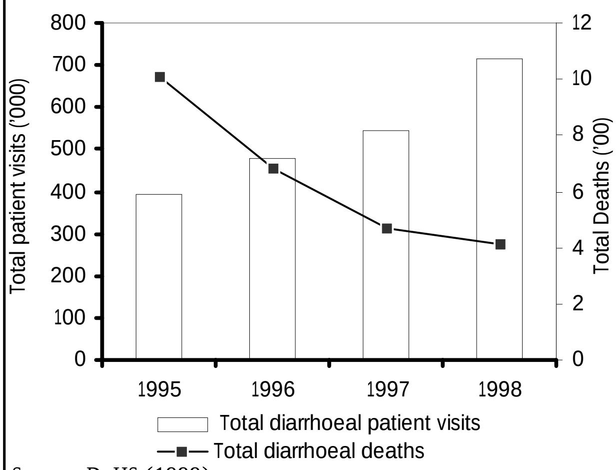
Source: DoHS (1999)

* Water-borne diseases like diarrhoea and typhoid result from the consumption of contaminated water; water-washed diseases like certain skin diseases and intestinal worms are caused by poor sanitation.

incidence of diarrhoea among children below five years of age was 131 per 1,000 children. The mortality rate due to diarrhoea was 0.34 per 1,000 children under five years of age, while the case fatality rate was 2.56 per 1,000 (CBS 1998).

On the whole, the incidence of diarrhoea is on the increase. A report obtained from Teku Hospital in Kathmandu shows that 16.5% of all deaths were due to water-borne diseases (Metcalf and Eddy 2000).

Figure 3.22: Diarrhoeal disease pattern in Nepal



Source: DoHS (1999)

Figure 3.22 indicates that the number of patients with diarrhoeal disease in the country increased, while deaths due to this disease have decreased. This clearly indicates that the government's attempts to minimise deaths from diarrhoea have been successful, but only limited attempts seem to have been made to control the disease through preventative measures. The latter are considered to be important for sustainable health. Map 3.10 depicts the relationship between potable water supply and water-borne disease by district, while Map 3.11 indicates the relationship between access to sanitation and water-washed diseases by district. There is a marked variation among the districts of Nepal in accessibility to drinking water and sanitation facilities and water-related disease patterns. Overall access to drinking water and sanitation facilities in the country is 61 and 21% respectively. In Nepal, water-related diseases have the highest share of the total OPD visits, of which diarrhoeal and skin diseases constitute 10% and 42% respectively (DoHS 1999).

The analysis of the accessibility of people to sanitary facilities versus water-washed diseases by district, as shown in Figure 3.23, shows that the relationship between them is very poor ($r^2 = 0.007$). Likewise, the relationship between potable water and water-borne diseases by district, as shown in Figure 3.24, is also very poor ($r^2 = 0.034$). From these analyses, it is clear that the water provided is not of potable standard and that the sanitary conditions are still inadequate to reduce the water-borne and water-washed diseases significantly.

Figure 3.23: Relationship between water-washed disease and sanitary facilities

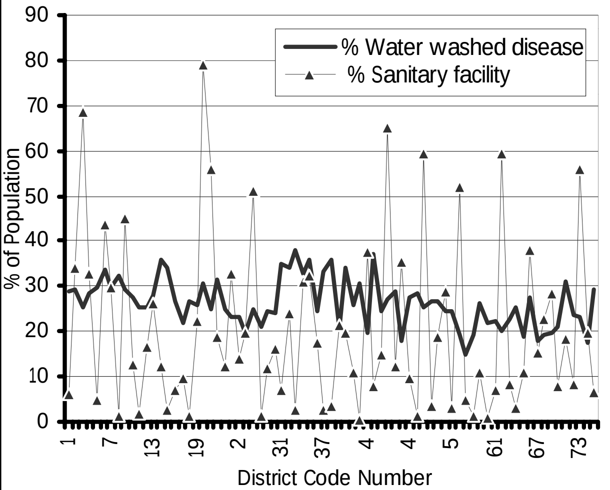
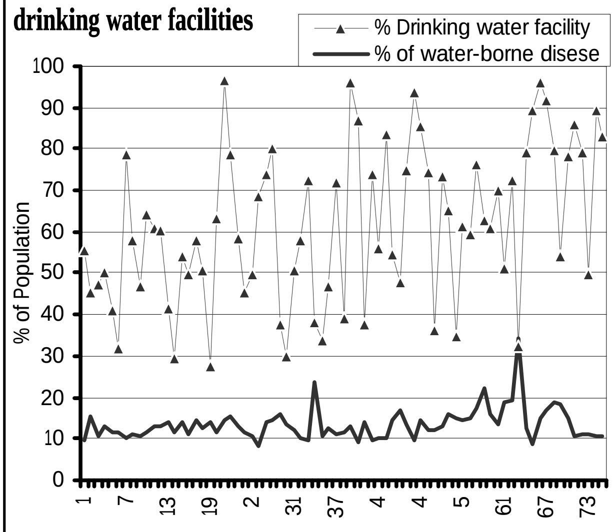
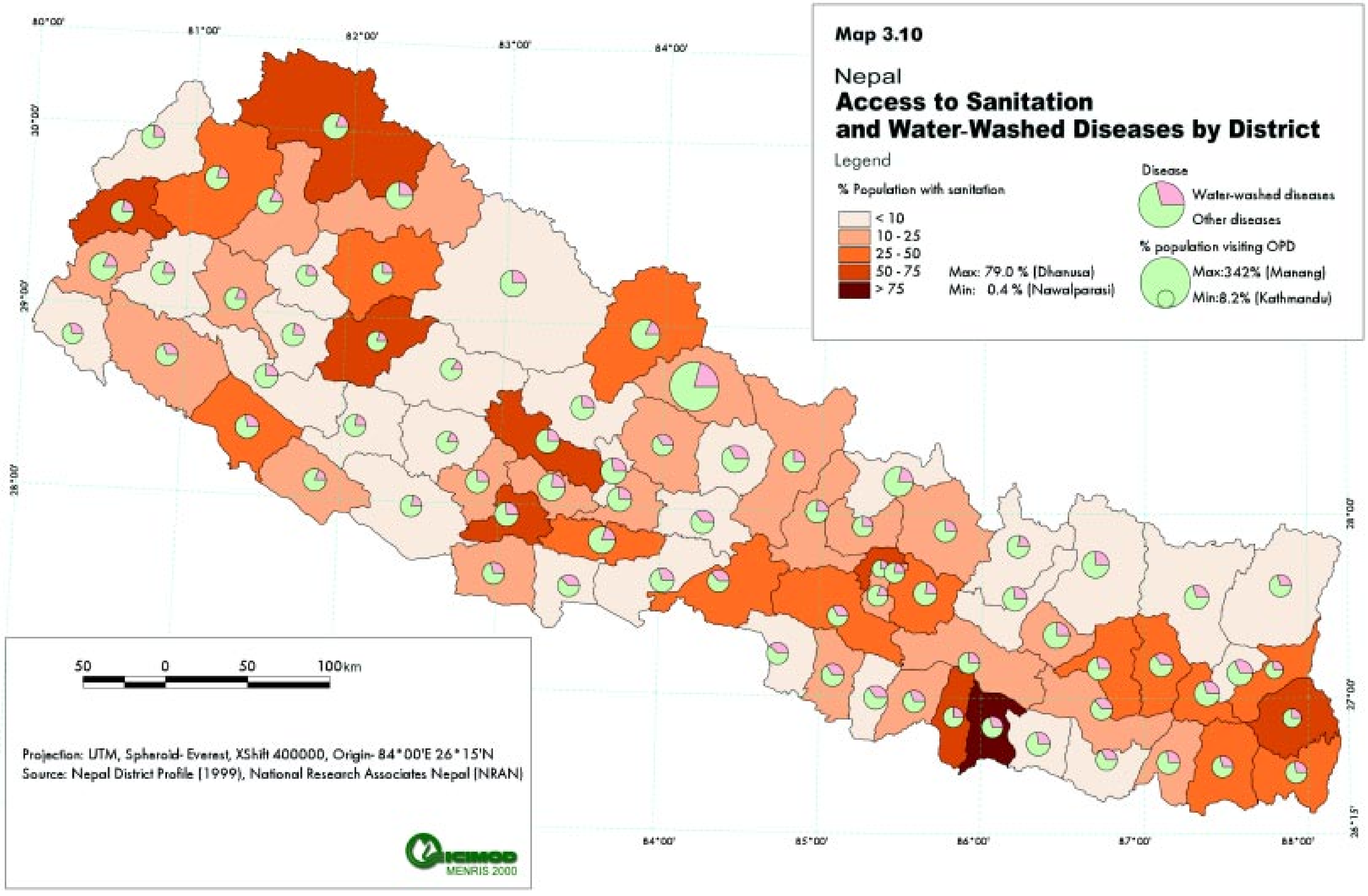


Figure 3.24: Relationship between water-borne disease and drinking water facilities



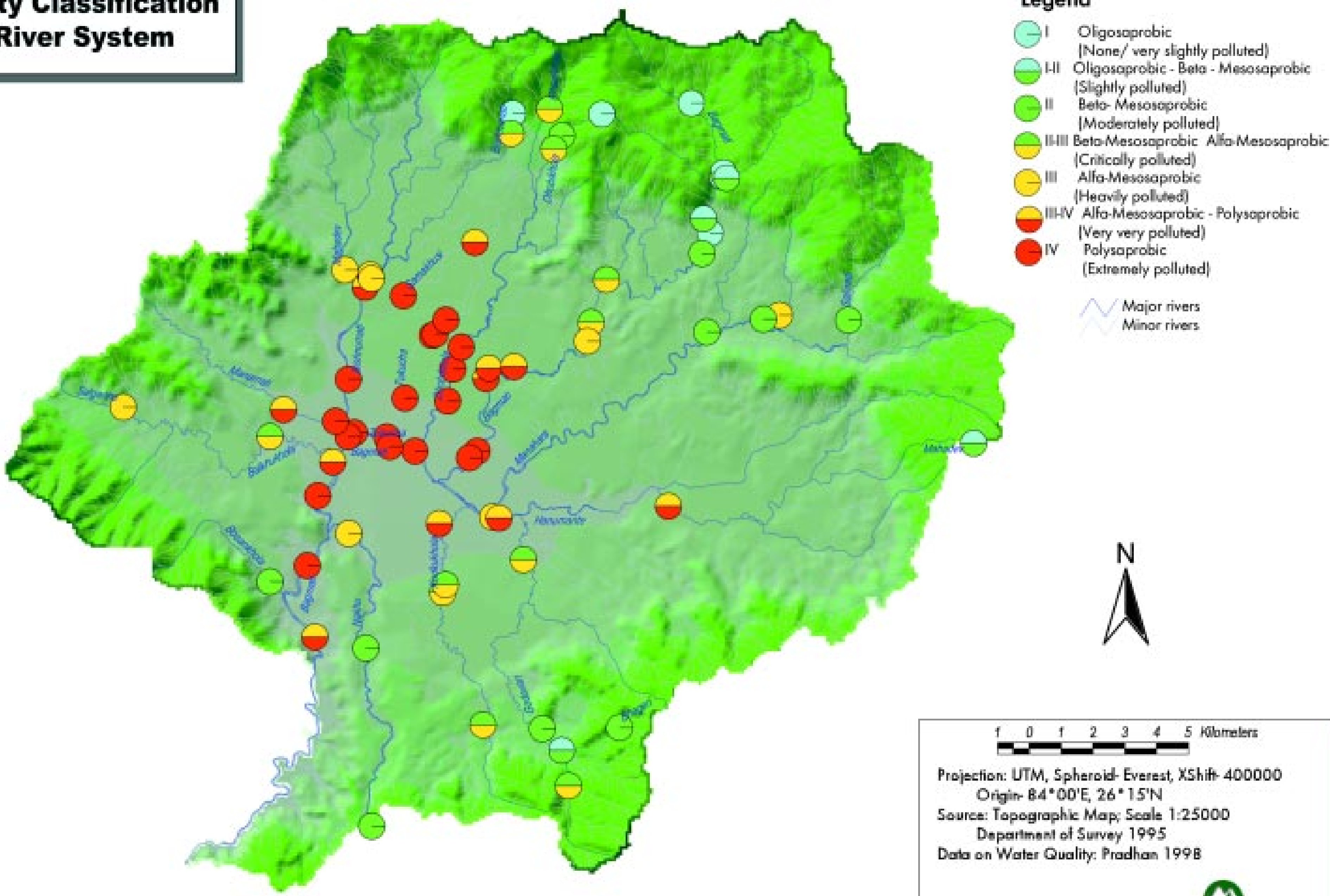
Map 3.10



Nepal
Access to Sanitation
and Water-Washed Diseases by District
Legend
% Population with sanitation
< 10
10 - 25
25 - 50
50 - 75
> 75
Max: 79.0 % (Dhanusa)
Min: 0.4 % (Nawalparasi)
Disease
Water-washed diseases
Other diseases
% population visiting OPD
Max:342% (Manang)
Min:8.2% (Kathmandu)
50 0 50 100km
Projection: UTM, Spheroid- Everest, XShift 400000, Origin- 84°00'E 26°15'N
Source: Nepal District Profile (1999), National Research Associates Nepal (NRAN)
MENRIS 2000

Map 3.11

Kathmandu Valley
Water Quality Classification of Bagmati River System



Projection: UTM, Spheroid- Everest, XShift- 400000
Origin- 84°00'E, 26°15'N
Source: Topographic Map; Scale 1:25000
Department of Survey 1995
Data on Water Quality: Pradhan 1998

ICIMOD MENRIS 2000

(b) Impact on water ecology

The economic use of local stream water is increasing. Using local rivers as sources of water for consumption and for irrigating vegetable fields are examples of their economic use. Both relate to urban demand. Quarrying of sand and stone from rivers is also intensifying because of urban demand (Plate 20). Such phenomena seem to have occurred basically in rivers flowing in and around large cities such as Kathmandu, Lalitpur, and Pokhara. These have caused the river water to become turbid.

Plate 20: Disturbance in the river ecology due to sand quarrying in the Manohara River, Kathmandu Valley (S. Shakya)

Cleaning vegetables with polluted river water for supply to the urban market may have adverse effects on human health. Bathing in polluted streams and rivers is also common practice, and this badly affects human health.

Economic activities and use of rivers for waste disposal can have an adverse impact on the aquatic flora and fauna of streams, ponds, and lakes; for instance, biodiversity is measured in terms of abundance and type of fauna, and both have declined sharply in the polluted section of the Bagmati River and its tributaries (Pradhan 1998).

(c) Impact on aesthetic values

In Nepal, water bodies like rivers, lakes, ponds, and spring sources (*kund*) are considered to be sacred places for performing religious activities. However, aesthetic values of water bodies have been greatly affected by haphazard construction of urban houses, encroaching on the river bank, dumping and discharging of household wastes and sewerage, discharge of industrial effluents into rivers, and quarrying of sand and stone (Plate 21). These activities, which are associated mostly with urban development, are considered injurious to the preservation of the aesthetic values of water bodies. They are not beneficial from an ecological perspective either.

Plate 21: Garbage dumped on the river bank leads to water pollution and loss of aesthetic value *(B. Pradhan)*

3.4.5 Responses

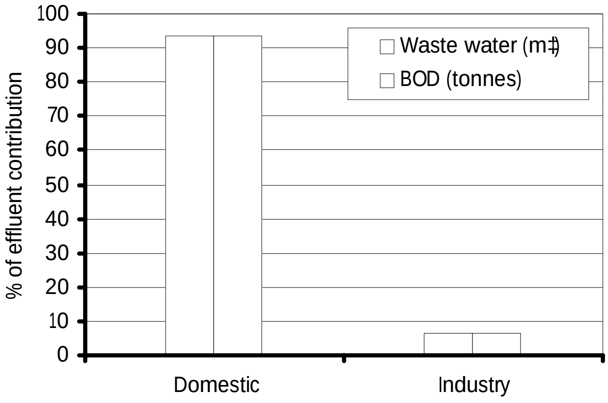
Realising the ecological, economic, and social importance of water resources, various attempts have been made by the government to improve the situation through adoption of various development programmes, organisational adjustments, and research activities. Government and semi-government organisations have been directly or indirectly involved in development, management, conservation, and planning of water resources in the country, either through their own efforts or through economic and/or technical assistance from international and bilateral agencies.

(a) Waste-water management efforts in Kathmandu city

Because of the direct discharge of waste water into rivers without treatment, all the rivers in Kathmandu Valley have been turned into open sewers. The study of Devkota and Neupane (1994) indicates that about 93% of the pollution load is from domestic sewage and the remaining 7% from industrial effluents (Figure 3.25). It has also been estimated that the present waste water production in the valley is 40 mld (CEMAT 1999). Table 3.39 summarises the total capacities and present condition of the four treatment plants in the Kathmandu Valley.

Very few industries in Nepal have treatment plants. Table 3.40 gives the types of effluent treatment plants in the country.

Figure 3.25: Domestic and industrial effluent contribution, Kathmandu Valley (1994)



Source: Devkota and Neupane (1994)

Table 3.39: Condition of waste-water treatment plants in Kathmandu

Treatment plant	Year of est.	Capacity mld	Type of plant	Area coverage	Existing situation
Hanumanghat	1975	0.5	Aerated lagoon	A part of Bhaktapur city	Operating inefficiently as a non-aerated lagoon
Sallaghari	1983	1	Aerated lagoon	North and south part of Bhaktapur city	Operating inefficiently as non-aerated lagoon and receives waste water only from the southern part of the city
Dhobighat	1982	15.4	Stabilisation pond	Waste water from the north-east part of Kathmandu	Out of order
Kodku	1982	1.1	Stabilisation pond	A part of Patan city	Operating inefficiently

Table 3.40: Industries with waste-water treatment plants in Nepal

Name of industry	Type of treatment
Colgate Palmolive	Primary treatment plant
Nepal Liver	Primary treatment plant
Shree Ram Sugar Industry	Anaerobic digester
Gorkha Brewery	Primary treatment plant
Surya Carpet Industry	Preliminary treatment
Narayani Leather	Chromium recovery unit & effluent treatment plant
Shree Distillery	Anaerobic digester
Tribeni Distillery	Anaerobic pond
Himal Distillary	Anaerobic digester
Everest Leather	Common effluent treatment plant
Source: Personal communication (2000)	

(b) Local initiatives

Some examples of successful local initiatives are shown in Boxes 3.5 to 3.7.

Box 3.5: Recycling used motor oil

Used motor oil from vehicles is becoming an extremely serious pollutant of surface and groundwater. The Chandra Lubricating Works (Pvt) Ltd in Birganj has been demonstrating since 1988 how to process such oil to make further use of it. The used oil is collected from garages. It undergoes a simple process to separate it into various grades of product. About half of the oil can be re-used as industrial grade oil and the waste is sold to local brick manufacturers as fuel for brick kilns. Thus it substitutes, to some extent, the need for industrial grade oil and fuel for the brick industry. The plant is a local initiative with very small capital. Such plants can easily be established elsewhere in other municipalities of Nepal.

Source: GTZ/UDLE/LUDTC (1992)

Box 3.6: NGO effort on waste-water management

Since 1997, an NGO called ENPHO has been installing and helping to operate small-scale localised waste water treatment plants, for example, at Teku for KMC, Dhulikhel Hospital, Malpi International School, and at Sushma Koirala Hospital in Sankhu. The treatment system is based on a constructed wetland system. KMC is collecting the sludge with 10-15 truckloads (each load with 6 m^3) from private houses' septic tanks and treats it before discharging it into the river.

Source: ENPHO (2000)

Box 3.7. The Gorkha Brewery treats its waste

The Gorkha Brewery of Nepal produces 2.5 million litres of beer a year. The Brewery has set up a sewage treatment plant to treat up to 35 cubic metres of water per hour. Besides, the Brewery is also able to sell sewage sludge as a soil conditioner.

Source: GTZ/UDLE/LUDTC (1992)

(c) Water rights

Awareness in local communities is rising about water use rights to streams flowing through their own areas. Upstream communities have begun to demand the right to control the use of water from streams originating or flowing through their own areas. For instance, the inhabitants of the Melamchi area have demanded the right to share in the use of the water of the Melamchi River with the inhabitants of the Kathmandu Valley for drinking purposes. They are demanding compensation for use of water from the river.

(d) Policy responses

(i) Legislation

Efforts to conserve water resources undertaken by the government through legal measures are summarised in the acts and regulations given below.

- Environmental Protection Act (EPA) (1996) and Environmental Protection Rules (EPR) (1997) and its Amendment (1999)

- Water Resources Act (1992), Water Resources Regulations (1993)
- Solid Waste Act (1987), Solid Waste Regulations (1989)
- Electricity Act (1992)
- Soil and Watershed Conservation Act (1982)
- Aquatic Animals Protection Act (1965)
- Patent, Design and Trademark Act (1965)

(ii) International conventions and treaties

Nepal is a party to a number of broader international conventions and treaties, including the Rio Conference of 1992 related to water, environment, and development. In addition, Nepal is committed to the following conventions, treaties, and agreements as shown in Table 3.41.

3.4.6 Conclusion

Although Nepal is rich in water resources, its people are not getting enough water to meet their needs nor is the available water potable. Incidence of water-borne diseases is rising mainly due to consumption of contaminated water.

Human activity is one of the major causes of polluted drinking water. The causes of water pollution are unprotected water sources, broken sewer lines, discharge of untreated industrial effluent into streams, municipal sewage, urban runoff, agricultural runoff, interrupted water supply, and open defaecation and garbage disposal in communal areas.

The issue of water pollution in the urban area of Nepal is related to the municipal sewerage system and storm-water drainage. The municipal sewerage system has a direct connection to the river environment since untreated sewage is discharged directly into rivers.

The existing laws and byelaws for managing the urban environment are not adequate. Furthermore, failure to enforce laws and byelaws and absence of clear-cut institutional responsibilities are major reasons for pollution of urban rivers.

Table 3.41: International conventions and treaties related to water quality

Conventions	Date	Nepal's signature	Main objective	Major obligation
Convention on Wetlands of International Importance especially as Waterfowl Habitat (Ramsar Convention)	2 Feb 1971	17 Dec 1987	Prevent the loss of wetlands	Conservation and sustainable use of migratory stocks of wildfowl
Agreement on the Network of Aquaculture Centres in Asia and the Pacific	8 Jan 1988	4 Jan 1990	Aquaculture development for increasing rural income	Expand network of aquaculture centres
Convention on Biological Diversity	5 Jun 1992	15 Jun 1992	Ensure conservation and sustainable use of biological resources	Prepare and implement national strategies for the conservation of biodiversity.

(a) Gaps

- Lack of data on water quality and quantity for all parts of the country
- Inadequate monitoring of water quality
- No lead agency to manage and coordinate water quality among the water organisations at national level
- Lack of a central data bank on water quality
- No water quality standards
- No drinking water guidelines for industrial effluents
- Lack of commitment in implementing and enforcement of industrial standards
- Lack of commitment in implementing water quality control measures
- Lack of effective awareness programmes at local level about the conservation of water sources
- Lack of storm-water drainage systems
- Lack of study on health impact of components such as Fe, As, NO_3, NH_4, Hg, Cr
- Lack of study on the impact of water pollution on tourism

(b) Recommendations

- Efforts for managing waste disposal, maintaining drinking water and sewer pipelines, controlling open defaecation, and imposing minimum urban housing standards are urgently required.
- The ongoing practice of direct discharge of domestic sewage and industrial waste into rivers is one of the main causes of pollution. To solve this problem a practical, reliable and cheaper method of treating effluent before being passed into the river should be sought; biological wastewater treatment would be one of the best alternatives. Such treatment plants should be planned to treat the majority of industrial and domestic waste.
- Introduce proper management of solid wastes
- Provide potable water to the general population; in the long run the cost for treated water would be less than the cost for medicines for curing water-borne diseases
- Set up a lead agency to coordinate water-related organisations, and for water quality control, management, and planning (urgent)
- Introduce a water quality monitoring programme at national level through a proper agency
- Provide appropriate techniques for rainwater harvesting, particularly for major urban areas in Nepal, as there is a great seasonal disparity in rainfall distribution
- Conduct effective awareness activities about conserving water quality and quantity in all parts of the country
- Introduce techniques to recycle domestic grey water
- Minimise leakage of piped drinking water through adopting efficient monitoring mechanisms
- Carry out research on water source protection and management
- Introduce on-site treatment plants for treating domestic waste at the community level
- Analyse the effect of water-borne pollutants such as heavy metals on health
- Adopt and enforce industrial effluent standards

(c) Emerging issues

(i) Inadequate supply of drinking water

This is basically related to the demand for water for household consumption and other economic activities such as industry, hotels and restaurants, transport, and others. The piped water supply is far below the needs of the people. The gap between demand and supply is widening each year.

(ii) Deteriorating quality of water

The quality of water for drinking purposes has deteriorated because of the inadequacy of treatment plants, direct discharge of untreated sewage into rivers, and inefficient technical management of the piped water distribution system. Also the quality of water in rivers, ponds, and lakes in major urban areas is deteriorating rapidly. As a consequence of such unhygienic water quality conditions, water-borne diseases such as diarrhoea, dysentery, and gastro-enteritis occur often. These diseases are prevalent in both urban and rural areas throughout the kingdom. The aesthetic value of the so-called sacred rivers, lakes, and ponds has been badly damaged. Therefore, their religious importance and recreational activities, such as bathing, swimming, and fishing in the rivers, have declined.

(iii) Depletion of groundwater table and drying up of spring sources and ponds
The overexploitation of groundwater not only affects the groundwater table but may also have adverse health effects due to the change in the geological source.

(iv) Water rights
Awareness in local communities of Nepal is rising about water-use rights to the streams flowing through their own areas.

3.4.7 Proposed projects

A cost analysis of some proposed projects related to water quality is given below.

Project 1: Water Quality Monitoring

Executive and promoting organisation:	Ministry of Physical Planning, Ministry of Population and Environment
Implementing organisation:	Local NGOs and other private firms working in related fields
Duration:	At least 2 years
Location:	All 58 municipalities of Nepal
Cost:	The estimated annual cost for all 58 municipalities is US$ 443,971. This includes the cost for labour, sample stations, kit boxes, lab costs, report preparation, and analysis.
Rationale:	There are no arrangements for water quality assessment in the majority of municipalities. Water quality assessment has been carried out in a few municipalities but not with continuous monitoring except for the Bagmati River and its tributaries in the Kathmandu Valley and the lakes in the Pokhara Valley. The quality of drinking water sources is not yet known widely. It is known from health bulletins that the number of people with water-related diseases is rising. It is important to know the status trends of water quality (both drinking water supply and water sources) in order to plan mitigation and treatment measures.
Methodology:	General basic parameters for water quality monitoring include pH, conductivity, chloride, ammonia, BOD_5, total phosphate, *E. coli* and heterotrophic bacteria count. In addition to these, other parameters such as Fe, Mn, and As are to be considered for groundwater. The methods

are both laboratory and kit-based and should be used by well-trained personnel. Sample stations should be located at one kilometre distances along each river. Sample sites should include every pond, lake, and spring and 20% of the public standing taps. Monthly collection of water with three replicates from each sample site is required. The central office will prepare reports on water quality based on records obtained from all field offices.

Project 2: Rainwater Harvesting

Executive and promoting organisation:	Ministry of Water Resources
Implementing organisation:	Local NGOs and other private firms working in related fields
Duration:	At least 3 years
Location:	Districts with limited supplies of both ground and surface water
Cost:	The cost is calculated for two purposes, for domestic use and for irrigation. The estimated cost per rainwater collection vessel per house is US$ 143 and masonry for irrigation is US$ 343.
Rationale:	Water supplies to most towns and settlements are inadequate. Piped drinking water is provided to only 62% of the total population. Many of the rural areas are without piped drinking water. People in the rural areas have to spend many hours a day fetching water for domestic uses. On the other hand, the national economy relies heavily on the agricultural sector, which in turn is squarely dependent on the monsoon rain due to grossly limited irrigation. About 70% of the precipitation occurs in the months of June-September during the monsoon season and the rest of the months receive little to no rain. Therefore, rainwater harvesting is deemed essential for both domestic and irrigation purposes.
Methodology:	For domestic purposes, including drinking and other uses, rainwater can be collected from the roof. A ferro-cement vessel for each house with the capacity to hold 2,000 litres of water is suggested. Research still needs to be done, however, into the optimum size needed. For irrigation water, particularly for dry land to grow cash crops, stone-cement masonry with a capacity of 10,000 litres of water is required. This has been shown to be sufficient to grow an additional cash crop on 1.5 hectares sq.km.

Project 3: Recycling of Grey Water, Shrestha (2000)

Executive and promoting organisation:	Kathmandu Metropolitan City
Implementing organisation:	Local NGO working in a related field
Duration:	2 years
Location:	Kathmandu
Cost:	The estimated cost per household is about US $ 360 one-time cost but this should be borne by the consumer. The maintenance cost is negligible. The cost to the project is that of production and distribution of IEC materials and maintenance of a demonstration site.
Rationale:	Shortage of drinking water is a serious problem in urban Kathmandu. The present water supply is 115 mld compared to the demand of 150 mld in the Valley. It is known that the government is not able to meet the present demand for water. Despite the scarcity of potable water, a preponderant proportion of the total water output is used for non-consumptive uses such as washing clothes and dishes, bathing, and toilet flushing. Only about 10% is used for drinking. It is estimated that about 70% of the water used in non-consumptive uses can be recycled by constructing wetland systems.
Methodology:	Recycling of waste water produced by non-consumptive sectors by wetland systems has been shown to be practical at the household level. The method does not require any subsidy. Only information, education, and communication (IEC) materials need to be made available free of cost. The implementing organisation will use the media basically for promoting contact among the public and will recommend who such a service can benefit.

References

Basnyat, B.B. (1999) *Fertilisers and the Environment in the Context of Nepal: How Big is the Problem?* Paper presented at the Workshop on 'Present Environmental Challenges and Management of Pesticides, Chemical Fertilisers and Solid Waste', 3-4 October 1999, SEJ Nepal, Kathmandu, Nepal

Bhusal, J.K. (1999) *Renewable Surface Waters of Nepal – Uses and Constraints to 21st Century.* Paper presented at the Third National Conference on Science and Technology, 8-11 March 1999, Kathmandu

CBS (1995) *Statistical Year Book of Nepal.* Kathmandu: CBS

CBS (1998) *A Compendium on Environmental Statistics 1998 Nepal.* Kathmandu: CBS

CEMAT (1999) *Report on Groundwater Monitoring Works of Kathmandu Valley*. Kathmandu: Urban Water Supply Reforms in the Kathmandu Valley Project

CEMAT (2000a) *Report on Surface Water Quality Monitoring Works of Kathmandu Valley*. Kathmandu: Urban Water Supply Reforms in the Kathmandu Valley Project

CEMAT (2000b) *Report on Waste Water Analysis of Kathmandu Valley*. Kathmandu: Urban Water Supply Reforms in the Kathmandu Valley Project

COSMOS (2000) *Water Quality of Phewa Lake* (unpublished). Kathmandu: COSMOS Engineering Service

Devkota, S.R.; Neupane, C.P. (1994) *Industrial Pollution Inventory of the Kathmandu Valley and Nepal*. Kathmandu: Industrial Pollution Control Management Project, HMG/MOI/UNIDO/91029

DFRS (1999) *Forest and Shrub Cover of Nepal*. Kathmandu: FSD

DHM (1999) *Water Quality of Rivers of Nepal* (unpublished). Kathmandu: DHM

DoHS (1998) *Annual Report (1997/98)*. Kathmandu: DHS

DoHS (1999) *Annual Report (1998/99)*. Kathmandu: DHS

ENPHO (1990) *Water Quality Assessment for Terai Tubewell Project*. Kathmandu: ENPHO

ENPHO (1995) *Limnological Investigation of Gosainkunda Lake and Impact of Janai Purnima Festival*. Kathmandu: ENPHO

ENPHO (1996a) *Trend of Degrading Water Quality of the Bagmati River (1988 - 1995)*. Kathmandu: ENPHO

ENPHO (1996b) *Report on the Water Source Monitoring Program for the Shivapuri Watershed by Assessing Water Quality* (First Phase). Kathmandu: ENPHO

ENPHO (1998a) *A Report on Water Quality Assessment of Lake Begnas and Rupa*. Kathmandu: ENPHO

ENPHO (1998b) *Monitoring and Assessment of Water Quality in the Shivpuri Watershed*. Kathmandu: ENPHO

ENPHO (1999) *Monitoring of Groundwater Quality in the Kathmandu Valley: Nepal-Stone Spout, a Traditional Water Source*. Institutional Strengthening of the MoPE(ADB TA 2817-NEP). Kathmandu: ENPHO

ENPHO (2000) *Kathmandu City Looking through the Eyes of ENPHO*, Environment and Public Health Organisation a Decade, 10th Anniversary Souvenir. Kathmandu: ENPHO

GEOCE (1999) *Environmental Monitoring and Management of East Rapti Irrigation Project*. Kathmandu: ADB/HMGN/MWR/DoI

GTZ/UDLE/LUDTC (1992) *Urban Environmental Guidelines for Nepal*. Kathmandu: GTZ/UDLE/HMG/LUDTC

IUCN (1991) *Environmental Pollution in Nepal: A Review of Studies*, Kathmandu: IUCN/NPC

Jha, M.G., Khadka, M.S., Shrestha, M.P., Regmi, S., Bauld, J. and Jacobson, G. (1997) *The Assessment of Groundwater Pollution in the Kathmandu Valley, Nepal*. Kathmandu: DoI/Australian Geological Survey Organisation

Metcalf and Eddy (2000) Paper presented at a Seminar on Groundwater and Waste Water, organised by Melamchi Water Supply Development Board, 14 February 2000, Kathmandu, Nepal

MoA (1998) *Statistical Information on Nepalese Agriculture*. Kathmandu: MoA, ASD

MoPE (1998), *Status of the Environment Nepal*. Kathmandu: MoPE

MOWR (1999) *Assessment of Water Resources and Water Demand by User Sectors in Nepal*. Kathmandu: MoWR

NEC/SEC (1999) *Final Report on the Development of Ambient Water Quality Standards for Different Uses*. Submitted to MoPE/HMG by Nepal Engineerng Consultants and Sujan Engineering Consultants

NESS (1995) *Research on Environmental Pollution and Management*. Kathmandu: Nepal Environmental and Scientific Services

NPC (1998) *The Ninth Plan (1997-2002)*. Kathmandu: NPC

NWSC (1999) *Water Supply and Coverage in Urban Area of Nepal*. Kathmandu: NWSC

Palikhe, B.R. (1999) *Pesticide Management in Nepal: Implementation Issues and Experiences*. Paper presented at the workshop on Present Environmental Challenges and Management of Pesticides, Chemical Fertilisers and Solid Waste, 3-4 October 1999, SEJ Nepal, Kathmandu, Nepal

Poudel, S.N. (1998) *Responses to Water Related Problems, A Compendium on Environmental Statistics*. Kathmandu: CBS

Pradhan, B. (1998) *Water Quality Assessment of the Bagmati River and its Tributaries, Kathmandu Valley, Nepal*, Ph.D. Thesis. Vienna: Department of Hydrobiology, Institute of Water Provision, Water Ecology and Waste Management, BOKU

Pradhan, P.K. (2000) *Urban Growth Pattern and Food Security in Kathmandu Valley*. Paper presented at the Workshop on Integrative Strategies for Food Security Improvements in the Kathmandu Valley, 30 April -1 May 2000, Kathmandu, Nepal

Pradhanang, T.M., Shrestha, P., Adhikari, R.; Upadhyaya, N.P.; Khadka, R.B. (1988) 'Effluent Impact of Bhrikuti and Everest Paper Mills on the Local Biotic Systems'. In *Journal of Nepal Chemical Society*, 8: 31-41

Sharma, S. (1998) *An Inventory of the Aquatic Insects of Nepal used as Bio-indicators of Water Pollution*. A report to the Secretariat of the University Grants Commission, Kathmandu, Nepal

Shrestha R.R (2000) 'Greywater Treatment: An Option for Water Recycling'. In *"Environment" A Journal of the Ministry of Population and Environment*, 5(6): 97-105

Shrestha R.R.; Manandhar, R. (1998) *Constructed Reed Bed – Technology Introduced for the First Time in Nepal*. Paper presented at the National Workshop on the 9th National Plan and Implementing Strategy in the WSS Sub-Sector, 22-23 March 1998, Kathmandu, Nepal

Shrestha, H.; Yogacharya, K.S.; Pradhan, B.K. (1996) *Indo-Bangladesh Sharing of Lean Stream Flowing of the Ganga and Farakka and Possibilities of Augumenting those Flows* (unpublished report)

Shrestha, R.R. (1999) *Application of Constructed Wetland for Wastewater treatment in Nepal*, Ph.D. Thesis. Vienna: Department of Hydrobiology, Institute of Water Provision, Water Ecology and Waste Management, BOKU

Stanley International/Mott-Macdonald/EAST Consultant (1994) *Report on the Bagmati Basin Water Management Strategy and Investment Program*. Kathmandu: East Consult

Tebbutt, T.H.Y. (1992) *Principles of Water Quality Control*. Oxford: Pergamon Press

UNICEF (1987) *Children and Women of Nepal: A Situation Analysis*. Kathmandu: UNICEF

WECS (1982) *Hydrological Studies in Nepal*. Kathmandu: WECS

WECS (1999) *Annual Report 1999*. Kathmandu: WECS

Yogacharya, K.S. (1996) *Assessment of Water Resources of Nepal and Its Economical* [sic] *Values*. Kathmandu: WECS

Yogacharya, K.S. (1998) 'Hydrometric Measurements in Nepal'. In *WECS Bulletin*, 9(1): 9-12

3.5 Air Pollution

3.5.1 Introduction

Air is a life-sustaining, precious natural resource. Air pollution adversely affects public health and the environment. Concentration of air pollutants is primarily a function of source emissions and meteorological conditions, which are closely related to population density and land-use patterns. In Nepal, man-made pollutants generally prevail in the air, in both urban and rural areas. Their effects can be observed much more readily in major cities and industrial areas. Transport, industry, road conditions, and ever increasing population flow towards large cities are major factors contributing to air pollution in large urban areas. Forest fires and dust generally pollute the air over rural areas. In the domestic sector, particularly in poorly ventilated houses, the use of traditional fuels like wood, cow-dung, and agricultural residues for cooking and heating has polluted the air, adversely affecting the health of the inhabitants.

3.5.2 Pressure

Air pollution is not a new phenomenon in Nepal, and it is now becoming the most rapidly growing environmental problem. There are a host of factors contributing to air pollution in Nepal.

(a) Energy consumption

Nepal's per capita energy consumption is about 336 kilogrammes of oil equivalent (kgoe) or 14 gigajoules (GJ). In 1998, the total energy demand in the country was estimated to be 7,340 thousand tonnes of oil equivalent (toe). There was an average increase of 3.3% per annum between 1980 and 1998 (Table 3.42). Out of the total energy consumption, 92% is consumed by the residential sector and the remaining 8% by other sectors (Figure 3.26). About 88% of the energy demand is met from traditional sources (fuelwood, agricultural residues, and animal dung). The remaining 12% is met from commercial sources such as petroleum products, coal, and electricity, with shares of 9, 2, and 1%, respectively (Figure 3.27). All petroleum products are imported into Nepal, of which a considerable amount is used for automobiles, followed by industry.

Table 3.42: Energy consumption pattern

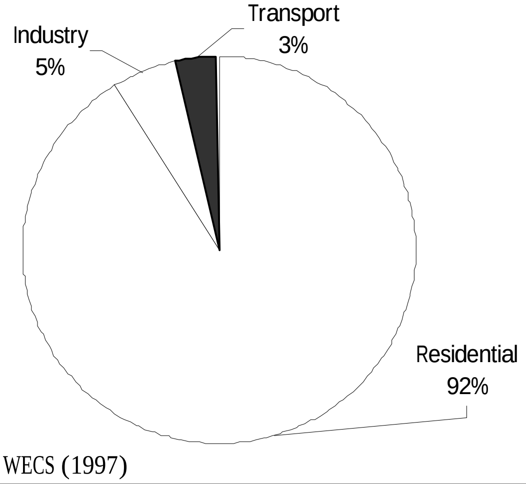
Energy used	1980	1985	1990	1995	1998
Traditional ('000 toe)	4411	4882	5395	6055	6458
Commercial ('000 toe)	180	267	293	549	882
Total ('000 toe)	4591	5149	5688	6604	7340
Per capita energy used (kg toe)	306	309	301	325	336

Source: WECS (1996); WECS (1999); CBS (1998)
toe = tonnes of oil equivalent

(b) Transportation

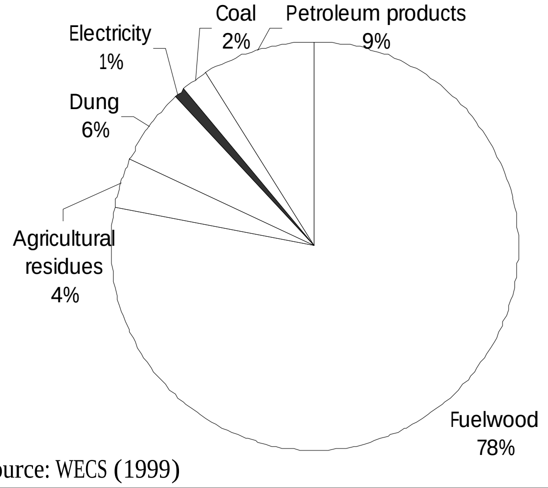
The expansion of roads has a great impact on the surrounding air in general, and on urban air in particular.

Figure 3.26: Energy consumption by sector



Source: WECS (1997)

Figure 3.27: Consumption of energy types



Source: WECS (1999)

Almost two-thirds of the total road length are gravel and earthen, contributing dust pollution to the air during the dry season. Black-topped roads account for only 33% of the total road length and are mostly concentrated in large urban areas (Table 3.43).

Of the total road length of 13,223 km in 1998, the Terai, with nearly 51%, had the biggest share, followed by the Hills with about 45% (DoR 1998).

Table 3.43: Road Status by Ecological Belt (1998)

Ecological Belt	Road Quality (km)			
	BT	GR	ER	Total
Mountain	181	195	179	555
Hills	2,353	2,162	2,220	5,935
Terai	2,353	2,162	2,220	6,734
Nepal Total	4,356	3,282	5,584	13,223
%	33	25	42	100

Source: DOR (1998). BT = Black Top; GR = Gravel, ER = Earthen

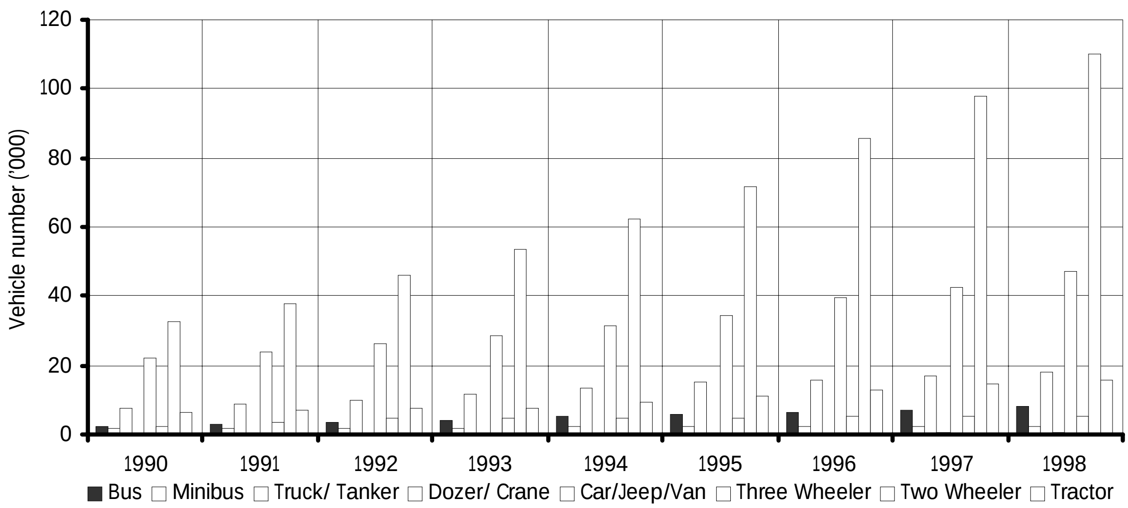
Along with the expansion of roads, the number of vehicles has also increased. The principal pollutants from vehicles are carbon monooxide (CO), hydrocarbons (HC), nitrogen dioxide (NO_2), odour, smoke, sulphur dioxide (SO_2), total suspended particulates (TSP), and soot.

The total number of vehicles increased from 75,141 in 1990 to 207,579 in 1998 (Figure 3.28). Two wheelers (motor cycles) accounted for the largest share (~ 51%), followed by light vehicles such as cars, jeeps, and vans (~ 22%). In 1998, the largest number of vehicles was registered in the Bagmati zone, which includes Kathmandu Valley, making up about 57% of the total vehicles registered in Nepal.

As a result, the consumption of petrol and diesel in the country has also risen considerably. The consumption of petrol was 17,241,000 litres in 1990 and increased to 49,994,000 litres in 1998. The consumption of diesel increased from 106,438,000 litres in 1990 to 315,780,000 litres in 1998. The Kathmandu Valley alone was responsible for about 73% of the total consumption of petrol in the country.

The vehicular traffic density contributes to localised air pollution. The density of vehicles for the country as a whole is 14 vehicles per km of road. For the Bagmati zone it was 51 vehicles per km of road for 1998.

Figure 3.28: Vehicle increment in Nepal

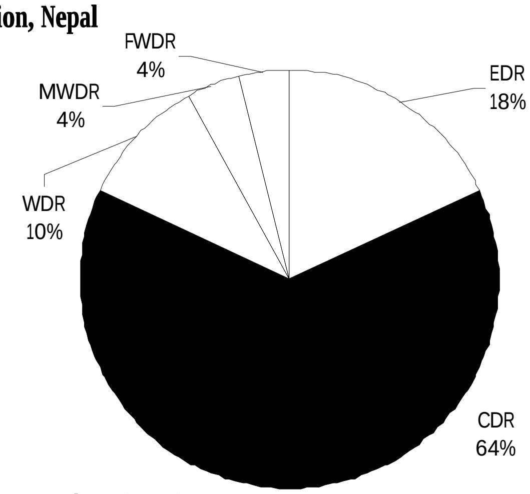


Source: CBS (1999)

(c) Expansion of industry

Together with the increase in the number of vehicles, the number of industries in Nepal has also increased tremendously. There were 4,487 industrial units in the country in 1994. Figure 3.29 shows that the Central Development Region had a share of 64%. The Kathmandu Valley had a share of 25%.

Figure 3.29: Distribution of industries by development region, Nepal



Source: Devkota (1998)

The industrial census of 1992 indicated that 74% of the total industries were air polluting industries and one-third of them were located in the Kathmandu Valley.

(d) Population growth and urbanisation

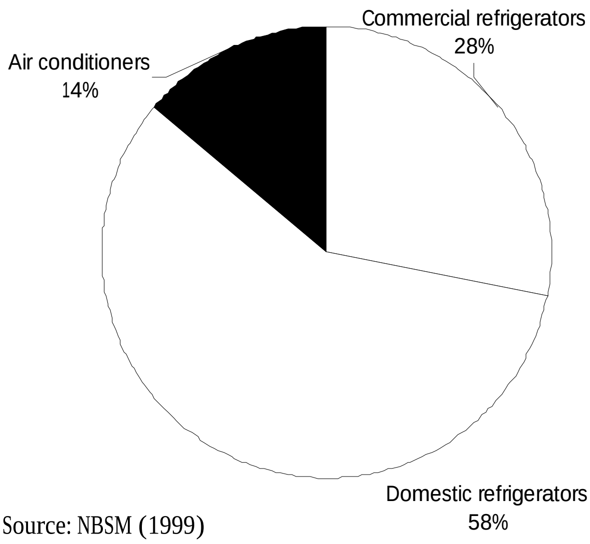
From 1981-91, the average annual growth rate of population in Nepal was 2.1%. It is estimated that, if this growth rate continues, Nepal's population will double in about 33 years. With about 15% of the urban population residing in 58 municipal areas, Nepal is one of the least urbanised countries in the world. However, the average annual growth rate of urban population of over five per cent is fairly high compared to that in other developing countries in Asia.

In Nepal, urban areas are more prone to air pollution than rural areas, because most of the municipal areas are connected by road and, therefore, more vehicles are plying the road. The roads are not well-maintained and neither are vehicles.

(e) Use of ozone depleting substances (ODS)

The people living in urban areas in Nepal are more used to modern amenities than those in rural areas. More and more urban inhabitants are able to enjoy a comfortable life with modern amenities such as refrigerators, air-conditioning, and the like. According to the survey carried out by NBSM (1999), chloroflurocarbon (CFC-12) and hydro-chloroflurocarbon (HCFC–22) were identified as ozone depleting substances (ODS). In 1996, the consumption of these two substances was 29.058 tonnes and 23.04 tonnes respectively. The country does not produce any ODS. All of these substances are imported from other countries. The annual per capita ODS consumption in Nepal is 0.0013 kg. Figure 3.30 shows that domestic refrigerators accounted for almost three-fifths of the total CFC-12 consumption.

Figure 3.30: Proportion of CFC-12 consumed, Nepal (1996)



Source: NBSM (1999)

(f) Other

Apart from the factors stated, the decrease in forests and shrubs in Nepal has also contributed to air pollution. The annual carbon release as a result of deforestation is estimated to be 7,768,000 tonnes (SEAMCAP 2000).

3.5.3 State

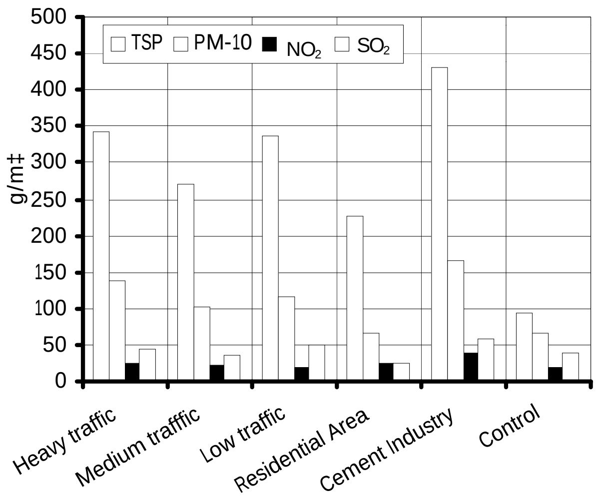
(a) Ambient air quality

The concentration of air pollutants is primarily due to source emissions and meteorological conditions, and these are closely related to population density and land-use patterns. Generally, there are more air pollutants from human activity in and around major cities and industrial areas than in rural areas.

(i) Ambient Air Quality in Kathmandu Valley

Information on ambient air quality is limited and most studies are concentrated in the Kathmandu Valley (IUCN 1992; ENPHO 1993; Devkota 1993; Shrestha and Malla 1996; URBAIR 1996; LEADERS 1998; ADB 1999; Kunwar 1999; NESS 1999). Factors such as rapid urbanisation, industrialisation, and poor maintenance of roads are important causes of air pollution in the valley. Figure 3.31 shows that the cement industry contributes the highest concentration of pollutants like total suspended particles and PM-10 (Plate 22). The total suspended particles and PM-10 values observed at different sample sites in the valley were found to be higher than the WHO guideline values (TSP – 120 µg/m^3 and PM-10 70 µg/m^3 for 8 hours) at all except residential and control sites (Shah and Nagpal 1997; NESS 1999). The other pollutants, NO_2 and SO_2, were below the WHO guideline values. The TSP in the ambient air in Kathmandu (Babar Mahal site) varied by month. Figure 3.32 indicates that the highest levels of TSP generally occurred during April or May, whereas the lowest were in July (DHM 1999). The TSP level is high in most areas in the Kathmandu Valley, and this is supported by the study of NESS (1999). The data are extrapolated in Map 3.12, which depicts the highest TSP level in the commercial area. Lead concentration in street dust and PM-10 in Kathmandu municipality were higher than the WHO guideline maximum (0.5 µg/m^3) (ENHOP 1993, Sharma and Upadhya 1995).

Figure 3.31: Ambient air quality in Kathmandu (1993)



Source: Shah and Nagpal (1997)

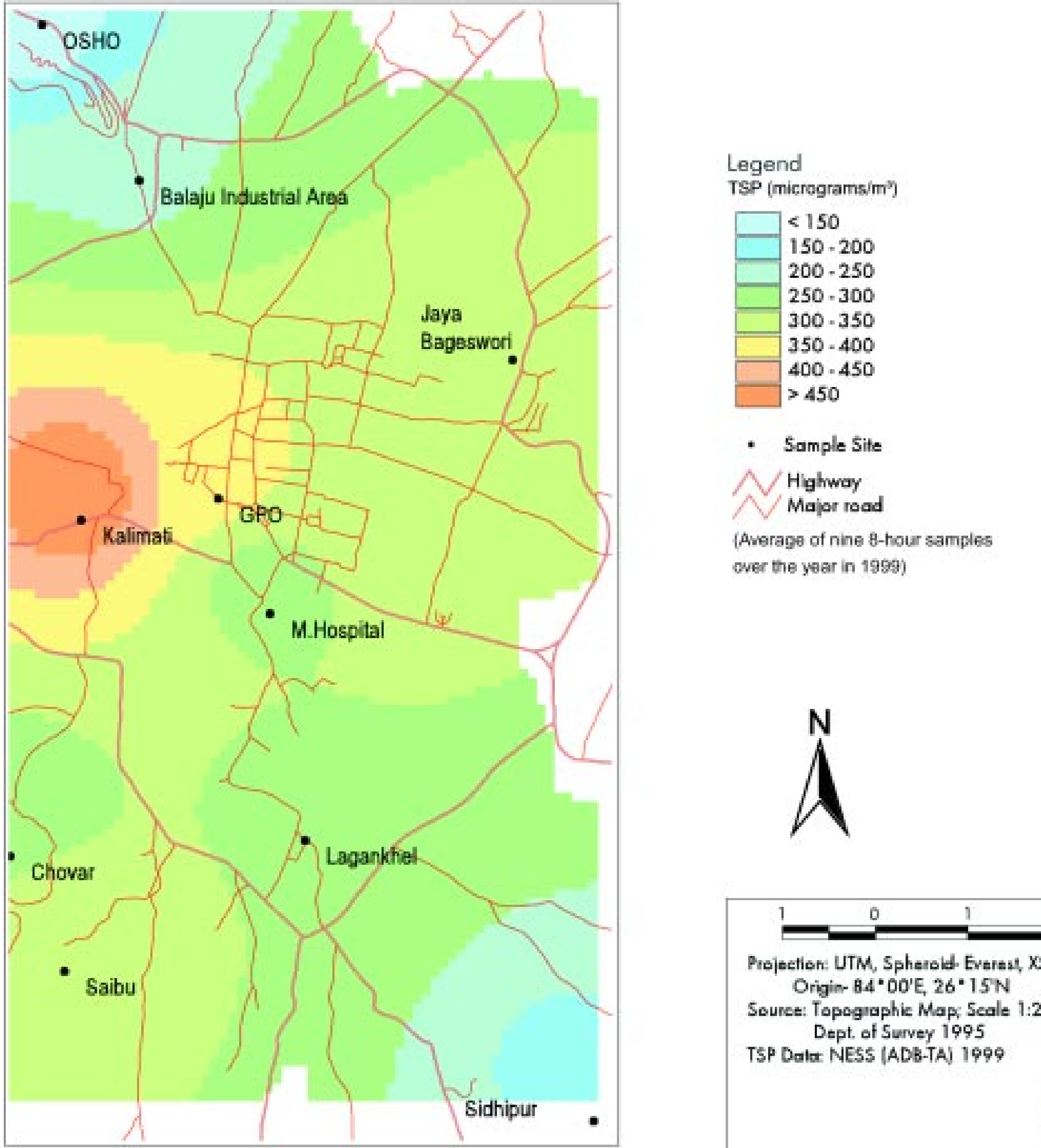
Plate 22: A cement factory emits dust and smoke to pollute the air surrounding the cities of Kathmandu Valley *(B. Banmali)*

Six pollutant indicator values were measured for three urban locations in the Kathmandu Valley. Thimi had the highest level of pollutants in all parameters except TSP (Table 3.44), even though

Map 3.12

Kathmandu Valley

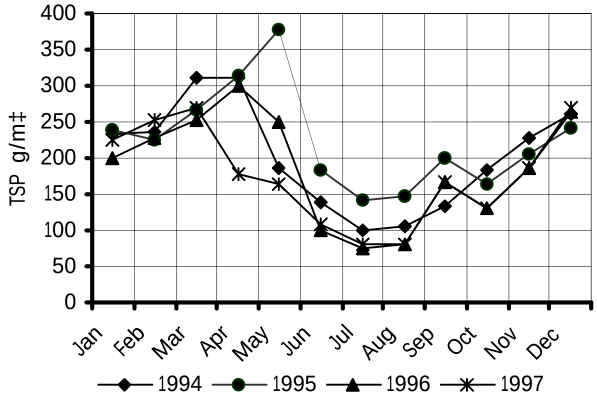
Concentration of Total Suspended Particles



Projection: UTM, Spheroid- Everest, XShift- 400000
Origin- 84°00'E, 26°15'N
Source: Topographic Map; Scale 1:25000
Dept. of Survey 1995
TSP Data: NESS (ADB-TA) 1999

ICIMOD MENRIS 2000

Figure 3.32: Total suspended particulates in ambient air, Kathmandu



Source: DHM (1999)

Table 3.44: Air quality at different locations in Kathmandu Valley

Location	TSP	Total PM-10	PM-10 carbon	PM-10 dust	SO_2	NO_2
Thimi	333	181	141	39	129	75
Bhaktapur	337	167	134	33	78	65
Kathmandu	357	160	113	27	50	46

Source: ADB (1999)

the traffic flow is comparably lower in Thimi than in the other two cities. This may be due to wind direction; the wind blows towards it from other parts of the valley. Equally there may have been a sizeable contribution from backyard potteries. According to WHO guideline values, the respirable particle PM-10, comprising mostly hydrocarbon, is relatively high in all three cities. This is mainly because of the exponential growth of automobiles, the narrow and poor condition of the roads, substandard fuel quality, and poor traffic management (ADB 1999).

Brick manufacturing is a significant source of atmospheric emissions because of the type of processes used in material handling and firing. Substantial amounts of 'dirty' fuels are consumed: burning efficiency is low, and there are no filters on the stacks. There are many brick manufacturers in the Valley (179 commerial kilns in 1994) mostly located near the outskirts of urban centres. The emission of pollutants is clearly visible (Plate 23) but exact quantification is difficult without stack monitoring. Secondary information estimates that tons of dust particles, SO_2, NO_2, hydrocarbons, carbon monoxide, and fluoride are emitted (NESS 1995).

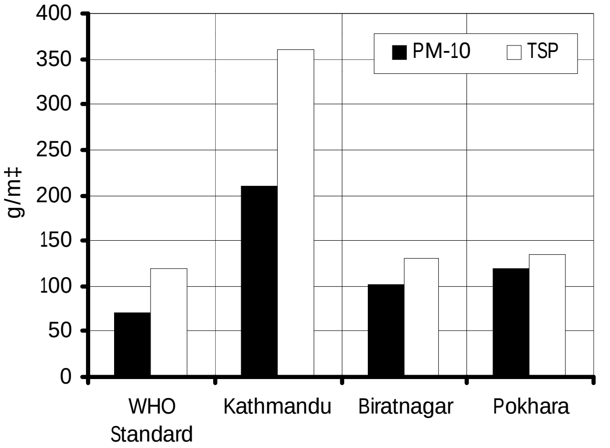
Plate 23: Release of huge emissions of smoke into the air by brick kilns in the Kathmandu Valley *(B. Banmali)*

Studies show that the Kathmandu Valley is particularly vulnerable to air pollution. This is not only due to the large number of vehicles plying the streets but also due to its bowl-shaped form which restricts wind movement within the Valley and retains the pollutants in the substratum, especially during periods of thermal inversion when warm air rests over cold air. This phenomenon often takes place in winter in the Valley.

(ii) Ambient air quality of the urban areas outside the Kathmandu Valley

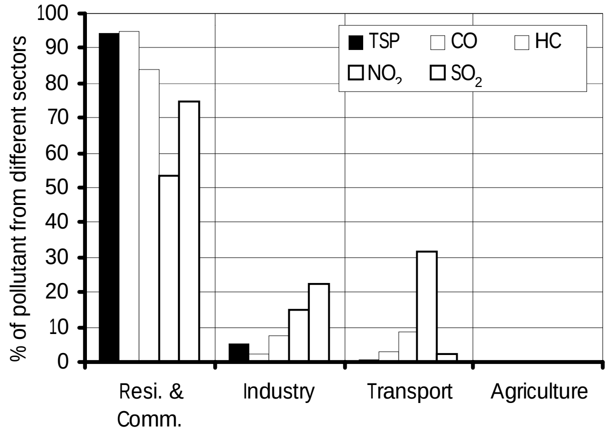
As shown in Figure 3.33, the highest average levels of TSP and PM-10 among the three major cities of Nepal are recorded in Kathmandu (Leaders 1999). The values of both parameters are higher than the WHO guideline values in all three cities (Figure 3.33). The highest value of both parameters in Kathmandu is due to its having the largest population, number of industrial units and vehicles, and road length.

Figure 3.33: Comparision of ambient air among major cities, Nepal



Source: LEADERS (1999)

Figure 3.34: Percentage of pollutant contribution by sector



Source: WECS (1997); SEAMCAP(2000)

(b) Emission of pollutants by sector

Ideally, estimation of emissions should be based on information on fuel type, technology, and operating conditions, together with national emission factors. However, in the present report the fuel type used in different sectors was used to estimate pollutant emissions based on the default emission factors published by US EPA (1992); Malla (1993); and URBAIR (1996). The pollutant emissions have been estimated for different sectors, viz., residential and commercial, industrial, agricultural, and transport. Table 3.45 depicts the estimated emission values of the five parameters TSP, carbon monoxide (CO), hydro-carbons (HC), nitrogen dioxide (NO_2), and sulphur dioxide (SO_2). Lead (Pb) was estimated only for the transport sector. The results are illustrated in Figure 3.34. The residential and commercial sector was the most important source of pollutants (Figure 3.34).

Table 3.45: Total emission (tonnes) by different sectors*

Year	Sector	TSP	CO	HC	NO_2	SO_2
1985	R-C	182,595.0	635,321.0	96,542.0	9,569.0	29,975.0
	I	3,913.2	6,026.6	6,740.3	758.1	1,026.2
	T	335	3717	2127	1437	149
	A	10.9	3.3	6.9	2.2	65.4
1990	R-C	204,381.0	730,359.0	108,903.0	10,907.0	35,630.0
	I	5,611.6	7,833.5	5,536.7	1,346.1	2,712.7
	T	809.0	9,003.7	4,981.1	3,586.5	349.0
	A	6.3	13.3	4.2	50.5	256.3
1995	R-C	235,406.0	853,782.0	125,857.0	12,780.0	42,064.0
	I	9,426.1	12,908.2	8,067.6	2,360.0	4,900.5
	T	1,676.6	18,585.4	10,634.9	7,186.2	744.4
	A	3.8	8.0	2.5	30.3	75.9
1996	R-C	246,528.0	744,500.0	121,850.0	12,972.0	25,870.0
	I	13,947.2	18,890.2	10,756.2	3,642.8	7,780.9
	T	1,838.7	21,435.7	12,427.0	7,695.7	808.4
	A	3.4	7.1	2.2	26.9	67.3

Source: Data from WECS (1997); estimation methods SEAMCAP (2000)
*Estimation of pollutants based on energy consumption
Note: R-C = residential and commercial, I = industry, T = transport, A = agriculture.

Fuelwood and other biomass are major sources of pollution in domestic and commercial areas of Nepal. Table 3.46 depicts the types of fuel used in the domestic and commercial sectors. Fuelwood was the most common source of fuel in both sectors, but there are considerable differences in percentage consumption (Table 3.46). The use of coal is negligible in the domestic sector, but it has the second highest percentage in the commercial sector (Table 3.46). Recently, in these sectors, the energy use pattern has shifted to some extent from traditional fuels to liquefied petroleum gas (LPG). This may have led to a decrease of CO and SO_2 emissions in these areas.

Table 3.46: Type of energy used in the domestic and commercial sectors (1996/97)

Types of fuel used	Energy used			
	Domestic		Commercial	
	'000 tonnes/Y	% per annum	'000 tonnes/Y	% per annum
Coal	2	0.01	36	25.5
Kerosene	177	1.02	33	23.4
LPG	18	0.10	13	9.2
Wood	14508	83.8	59	41.8
Vegetable wastes	872	5.04	0	0.0
Animal waste	1720	9.94	0	0.0
	17297	100	141	100.

Source: WECS (1997)

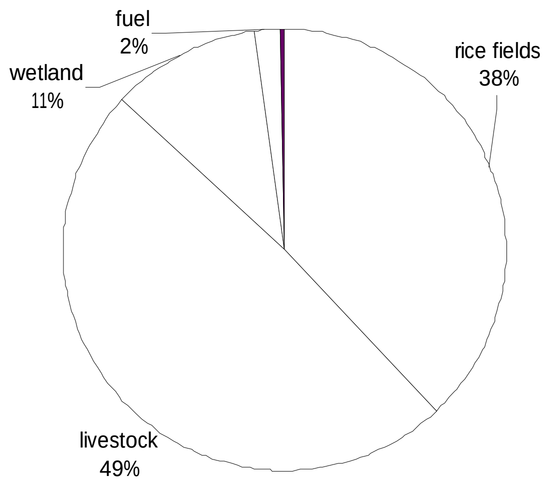
The transportation sector relies mostly on petroleum products; the largest usage is for diesel, which accounted for 66% of the total fuel consumption of 240,000 toe in 1996/97. The other fuel types are coal, air turbine fuel, and motor spirit, which accounted for 3, 15, and 16%, respectively. The estimated emissions of Pb from leaded petrol used in the transport sector were 1.6, 3.1, and 3.5 tonnes/year in 1990, 1995, and 1996, respectively (WECS 1997). As electric vehicles and unleaded petrol for automobiles were introduced in 1999, the level of pollution related to the transport sector is expected to decrease in coming years.

The consumption of energy by the agricultural sector is the lowest among the four sectors (Table 3.45). Emission is totally dependent on the consumption of high-speed diesel oil. The largest amount of gas emitted by this sector is sulphur dioxide .

(c) Emission of greenhouse cases

The combustion of fossil fuels, deforestation, and land-use changes are major sources of greenhouse gases (GHGs) which include carbon dioxide (CO_2), methane (CH_4), and NO_x. Between 1960 and 1990, the emission of CO_2 as a result of deforestation and land-use change in Nepal was estimated have to increased from 3.96×10^6 to 15.45×10^7 tonnes/year (Hall and Uhlig 1991; Devkota 1992). Annual emission of GHGs because of use of petroleum products was estimated as 72,000 tonnes of carbon (C) and 1,790 tonnes of nitrogen (N) between 1970 and 1990 (Devkota 1992). Boden et al. (1995) estimated an emission of 354,000 tonnes of CO_2 in 1992 caused by combustion of fossil fuels. The average production of CH_4 was 1.2 million tonnes in 1997. Figure 3.35 shows that CH_4 emission was the greatest from the livestock sector, followed by rice fields, among others.

Figure 3.35: Methane emission by sector



Source: MoA (1999); SEAMCAP (2000)

3.5.4 Impacts

The harmful effects of atmospheric pollution are widespread and varied. There is no doubt that concentrated atmospheric pollution in particular locations has caused adverse effects on human health and biotic life.

(a) Health

Adverse effects of air pollutants on human health can be acute or chronic. Acute effects manifest themselves immediately upon short-term exposure to high concentration of air pollutants, whereas chronic effects become evident only after continuous exposure to low levels of pollutants.

Medical records from hospitals in the Kathmandu Valley revealed that urban residents have more respiratory diseases than rural residents (LEADERS 1999). This may be due to deterioration in air quality in urban centres. Acute respiratory infection (ARI) is one of the top five diseases. Table 3.47 shows that ARI was the reason for 12% of outpatient visits (DoHS 1999). The highest percentage share of ARI patients is from the Hills (Figure 3.36).

Table 3.47: Respiratory disease (RD) pattern, Nepal

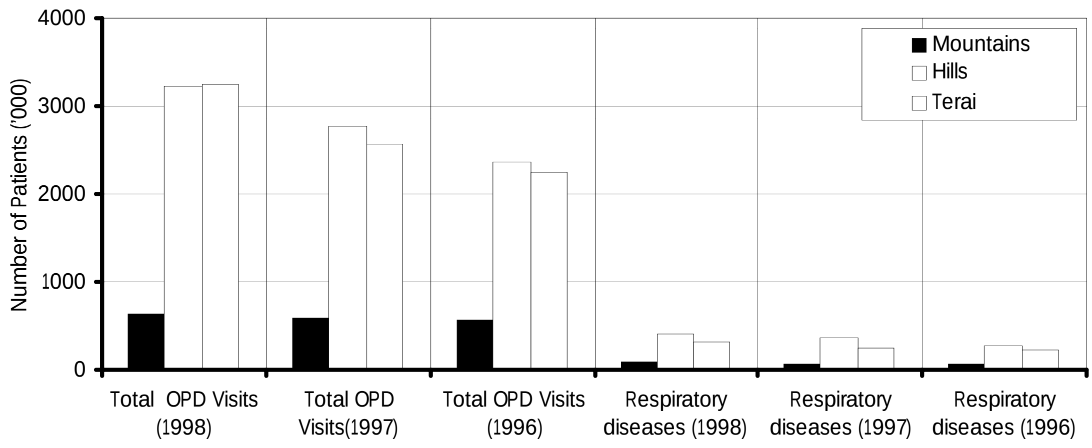
Geographical region	Total OPD Visit	Total RD Patients	RD Patients as % of total OPD visits
Mountains	645,992	85,872	13
Hills	3,230,701	420,037	13
Terai	3,239,288	321,680	10
Total	7,115,981	827,589	12

Source: DOHS (1999)

Respiratory diseases occur mainly as a result of prolonged exposure to smoke and dust (Pandey and Basnet 1987). ARI continues to be the leading cause of death among young children, accounting for more than 30% of deaths in children under five years of age (Niraula 1998).

Pandey and Basnet (1987) have found a strong correlation between the prevalence of chronic bronchitis and indoor smoke pollution in Nepal. It was reported that 31% of the bronchitis cases were due to indoor smoke pollution in Jumla district in Far West Nepal, 17% in Sundarijal and Bhadrabas in Kathmandu district, 13% in Parasauni in Bara district (Central Terai), and 11% in urban Kathmandu. They indicated that twice as many traditional cooking stove owners than improved cooking stove owners complained of eye irritation and coughing. The indoor air in most rural areas is polluted because of combustion of biomass in poorly ventilated rooms.

Figure 3.36: Total OPD visits and respiratory diseases, Nepal



Source: DoHS (1998, 1999)

(b) Vegetation

ENPHO (1999) reported that the activities of Himal Cement have had a negative impact on vegetation in the surrounding area. The study showed that foliar injury and low yield of crops were due to photosynthetic disturbance as dust deposition on leaves blocked the stomata. The soil became hard because of calcium deposition, affecting the germination of seeds. Among the plants, *Pinus roxburghii* was the most affected because of the resiniferous nature of the plant.

(c) Visibility

The atmospheric data obtained from the Kathmandu airport from 1970 onwards show that there has been a very substantial decrease in visibility in the valley since 1980. The number of days with good visibility (> 8,000m) around noon decreased in the winter months from more than 25 days/month in 1970 to 5 days/month in 1992. Low visibility and poor sunlight during the winter are also associated with dust from Himal Cement.

3.5.5 Responses

The government has formulated the following acts and policies to combat air pollution in the country.

(a) Legislation

- Constitution of the Kingdom of Nepal (1990)
  - The state shall give priority to protecting the environment and take special measures for preventing further damage due to physical development activities
- Industrial Enterprises Act (1992)
  - Specific for the prevention of environmental pollution and its effect on public health
- Labour Act (1992)
  - A healthy, safe, and secure environment for workers
  - Ensure solid waste management and control of noise and air pollution
- Vehicle and Transport Management Act (1993)
  - Empowers the government to set emission standards for vehicles and enforce them in practice.
- Environmental Protection Act (1996)
  - A comprehensive act to regulate and control pollution levels in the country
  - MoPE is empowered to prohibit the use of any matter, fuel, equipment, or plant that has or is likely to have adverse effects on the environment.
  - Endorsed National EIA guidelines (1993)
- Local Self-governance Act (1998)
  - Entrusts municipalities with various responsibilities and rights with respect to environmental protection

(b) Policies

- National Conservation Strategy (1988)
  - Recommended policy with respect to air, noise, and water pollution
  - Industrial effluent discharge, noise abatement standards, and correlative mitigation and preventative measures
  - Establishment of air and water quality monitoring and evaluation systems
- The Eighth-Plan (1992-1997)
  - Ministry of Population and Environment established
  - Enactment of Environmental Protection Act (1996) and promulgation of Environmental Regulations (1997)

- The Ninth-Plan (1998-2003)
  - Formulation of air, water, noise, and land-related pollution control management plans
  - Vehicular emission standards fixed
  - Mentioned the establishment and implementation of emission standards for air pollution and an appropriate management plan to check emissions from industrial premises
  - Commitment for specifying air pollution standards
- Nepal Environmental Policy and Action Plan (1993) (NEPAP)

(c) Policy response: activities implemented to mitigate air pollution

- Introduced the vehicle exhaust emission test in 1994 following the tail-pipe standards of 65 Hartridge Smoke Units (HSU) for diesel-operated vehicles and three per cent of carbon monoxide (CO) for petrol-operated vehicles
- Nepal Vehicle Mass Emission Standards 2056 (1999), similar to the European Union Standard (EURO-1) to reduce the emissions per kilometre of vehicles. Prohibited to register two-stroke engine vehicles in three major tourist places: Kathmandu Valley, Pokhara, and Lumbini
- Since 30th August 1999, the three-wheeler diesel tempo has been banned in the Kathmandu Valley. Instead, electric vehicles, known as 'Safa tempo', and LPG three-wheeler or 'tuktuk' have been introduced by MoPE (2000) (Plate 24).
- Public announcement of the distribution of unleaded petrol was made on 26th December 1999
- EIA guidelines for the industrial sector and the environment and risk assessment guidelines have been prepared.

Plate 24: Introduction of electric vehicles to replace three-wheeler diesel vehicles: an encouraging endeavour for controlling air pollution (B. Banmali)

Box: 3.8: Status of clean production practices of Nepalese industries

The Ministry of Industry, His Majesty's Government, with the assistance of UNIDO and UNDP, introduced a cleaner production (CP) programme for the first time in Nepal in 1997. The programme was introduced with the objective of formulating and implementing policies for industrial pollution control and discharge standards. The programme was introduced by demonstrating its financial and environmental benefits as well as its potential as an effective tool for reduction of pollution for potential stakeholders, including industrial enterprises and industrial environment-related non-government organisations. Awareness of the CP programme has also been promoted in relevant institutions such as the government, private sector, industrial associations, research organisations, NGOs, and journalists' groups through workshops and training in different parts of the country.

A draft policy paper has already been prepared. Discussions on it at various levels, such as with related government policy personnel, stakeholders, and political parties, have yet to take place. HMG has yet to endorse it for adoption as a government policy. The policy working paper was prepared based on information obtained from field observations, a few industrial case studies, and workshops.

Source: Manandhar (2000)

- Introduced a project on establishing air quality monitoring stations in the Kathmandu Valley with Danish assistance. Air quality monitoring activities are being carried out at different levels in different parts of the country by various organisations, including the government, NGOs, INGOs, and the private sectors.
- Adopted an appropriate technology for alternative energy to help reduce the great dependency on traditional energy sources; the Alternative Energy Promotion Centre (AEPC) has prepared a 20-year Master Plan on alternative energy
- During the Eighth Plan period (1991-96), a total of 32,119 biogas plants was installed, generating 75 megawatts of energy annually. As this was small compared to the total potential production of 2,400 megawatts, the Ninth Plan (1997-2002) proposed installation of an additional 90,000 biogas plants.
- Introduced the Improved Cooking Stove (ICS) programme in 1950 to prevent indoor pollution. About 88,000 ICSs have already been installed. The Ninth Plan aimed to install about 150,000 stoves in 45 districts. The non-government sector has also been involved in installing an additional 100,000 improved stoves.
- About 300 solar dryers are to be installed during the Ninth Plan period in order to increase the income of rural communities.
- The Ninth Plan has a scheme to install solar energy photovoltaic systems in 38,000 households in remote places where it is not feasible to link with the central grid systems and where micro-hydro electricity is not feasible.
- To encourage the use of alternative energy, subsidies have been given as follow.
  - Solar photovoltaic - 50% subsidy
  - PV pumping system - 75% subsidy
  - Solar dryer - 50% subsidy (1998)
  - Biogas plants - variable subsidy

(d) Nepal's signature on international conventions and treaties

Nepal has signed various international conventions and treaties related to air pollution, as shown in Table 3.48.

Table 3.48: International conventions and treaties on air pollution

Description	Date	Nepal's signature	Main objectives	Major obligations
Vienna Convention for the Protection of the Ozone Layer	22 Mar 1985	6 Apr 1994	Protect human health and the environment against adverse effects of modification of the ozone layer	Limit the use of ozone layer depleting substances
Montreal Protocol on Substances that Deplete the Ozone Layer	16 Sep 1987	6 Jul 1994	Protect the ozone layer by controlling the emissions of sub-stances that deplete it	Control annual consumption and production of substances that deplete the zone layer
London Amendment to the Montreal Protocol on Substances that Deplete the Ozone Layer	29 Jun 1990	6 Jul 6 1994	Strengthen the control procedures and establish a financial mechanism for the Protocol	Phase out the production of substances that deplete the ozone layer and establish financial mechanisms and a clearing-house function for implementation of the Protocol
United Nations Framework Convention on Climate Change	5 Jun 1992	12 Jun 1992	Stabilise greenhouse gas concentrations in the atmosphere within a time frame	Adopt precautionary measures to minimise or prevent the release of greenhouse gases and mitigate the effects of climate change

3.5.6 Conclusion

The sources of air pollution in Nepal are varied and include combustion of fossil fuel, vehicular exhaust, industrial emissions and effluents, unmanaged solid waste, and smoke emissions caused by combustion of biomass.

At present, the air pollution problem of immediate concern includes particulate matter in major urban areas. Indoor air quality is aggravated by the extensive use of biomass as a source of energy. Ongoing development activities and changes in lifestyles, particularly in the large cities, have caused an increase in concentrations of air pollutants such as TSP, CO, Pb, SO_2, NO_2 in the ambient air. Therefore, Nepal needs to introduce measures, first focusing on preventing the problems of air pollution at source, and then on control measures to abate other problems.

A wide data gap exists on different aspects of air pollution, as well as between Kathmandu and other parts of the country. In many parts of the country, no monitoring of air pollution caused by different factors has been carried out. Every municipality should introduce measures to control air pollution according to its own requirements under the Local Governance Act. For instance, Pokhara sub-metropolitan area restricted the use of diesel operated, three-wheeled vehicles some years ago.

(a) Gaps

- Assessment of air quality has not been carried out systematically in Nepal because of lack of a strategic air quality monitoring policy, infrastructure, and technology. Furthermore, the concept of an Air Quality Management System (AQMS) is absent from the national policy.
- Similarly, there is no Air Quality Information System (AQIS), and this has limited the scope for comprehensive presentation of the state of the atmospheric environment.
- No ambient air quality standards
- Low priority is given to research work
- No organisation responsible for air quality monitoring
- Lack of quality assurance
- Lack of information on ambient air quality near brick and other air polluting industries
- Paucity of information on the impact of air pollution on tourism
- Lack of data on the impact of the brick and cement industries on human health, and biotic and abiotic components

(b) Recommendations

(i) General

- Establishment of air quality monitoring stations at major traffic points, industrial areas, and major commercial points
- Mass awareness programmes
- Provision of mass transportation
- Carry out studies on the impacts of air pollution on the general health of people, and on abiotic and biotic components

(ii) Specific

- Air quality standards to be established
- Policy framework for promotion of alternative fuels to bring down fuelwood consumption
- Promotion of mass transport systems (private sector)
- Proper road planning for cities
- Promotion of cleaner fuels
  - Unleaded fuels (catalytic converters)
  - Desulphurisation of diesel

- Policy to phase out old vehicles
- Improve industrial boiler efficiency and introduce cleaner technology for brick kilns
- Proper implementation of Euro standards
- Cleaner production should be made mandatory for small-scale industries, and proper standards for large-scale industries.
- Industrial zoning and the movement of industries away from residential areas and environmentally sensitive sites should be considered.
- IEE/EIA should be seriously implemented in new industrial establishments.

3.5.7 Proposed projects

A cost analysis of some proposed projects related to air pollution control is given below.

Project 1: Industrial Pollution Monitoring

Introduction:	Industrial pollution monitoring includes water and air
Executive and promoting organisation:	Ministry of Industry and Ministry of Population and Environment
Implementing organisation:	Local NGOs and other private firms working in the related field
Duration:	At least 2 years
Location:	Districts having an agglomeration of pollution-related industries at a particular location
Cost:	The estimated cost per industry per year is US$ 3,890.
Rationale:	Industries causing pollution in Nepal number 3,320, making up 74% of the total industrial units. Most of the polluting industries are found to be located in major urban centres, the largest being the Kathmandu Valley and its cities. Due to lack of regular monitoring of polluting industries, no mandatory policies exist in Nepal. In order to formulate sound, mandatory policies, regular monitoring of all polluting industries is essential in order to supply reliable information.
Methodology:	For industries polluting rivers, at least two sample points – before and after the mixing of industrial effluents – are required for each industry with three replicates for each site and sampled at lease four times to cover the four seasons each year. Basic parameters include BOD_5, COD, pH, conductivity, chloride, TSS, TDS, nickel, chromium, soap, and oil and grease, as well as bacteriological aspects such as *E. coli* and coliforms. For air pollution, stack monitoring is used. One stack per industry with three replicates sampled four times (once per season) a year is required. Parameters to be included are TSP, PM-10, SO_x, NO_x, and CO.

Project 2: Ambient Air Quality

Executive and promoting organisation:	Ministry of Population and Environment
Implementing organisation:	Local NGOs and other private firms working in related fields
Duration:	At least 2 years
Location:	Municipalities and industrial areas
Cost:	The cost is calculated at US$ 90,000.
Rationale:	The ambient air quality of indoor as well as outdoor urban and rural areas in Nepal has deteriorated. Even the air in rural areas is not safe because of transboundary movement of pollutants. Yet we do not know anything about the air quality in rural areas. Pollution levels have increased because of the expansion of roads, an increase in the number of vehicles, and an increase in the use of equipment producing ODS. The number of persons suffering from respiratory diseases is also increasing. The quality of data on air is poor, as quality is mainly calculated considering the total energy used by the IPCC method. Due to the lack of air quality monitoring data, the air quality standard cannot be determined.
Methodology:	Basic parameters like TSP, PM-10, NO_x, SO_x, CO_x, and ozone will be considered for analysis. Each study area will be divided into four sections: commercial, residential, industrial, and reference. From each site one sample with three replicates for each of the four seasons in a year will be considered. Analysis of the parameters will be carried out following standard methods, (for example from UNEP's GEMS-Air)

Project 3: Solar Drying Systems

Executive and promoting organisation:	Ministry of Science and Technology
Implementing organisation:	Local NGOs and private firms working in related fields
Duration:	At least 3 years
Location:	Rural Nepal
Cost:	The cost is calculated as US$ 30 – 340 per dryer.
Rationale:	Nepal gets an average of 300 sunny days per year and

global insolation is favourable in many locations for the exploitation of this energy. Though the average solar radiation is not equal in all parts of Nepal, the potential for solar energy is fairly high. The amount of insolation in Nepal's landmass is 26.6 x 10^6 MW. The traditional use of solar energy is mainly for drying agricultural products. Traditional sun drying is performed on the open ground. The disadvantages associated with this are that the process is slow, insects contaminate the products, and dust gets mixed in with them. The use of a dryer helps to eliminate these disadvantages. Drying can be done much faster and safer as the contamination is controlled in the enclosed chamber of the dryer.

Methodology: IEC regarding solar dryers will be given and loans provided for installation.There will be a training programme for each community regarding techniques of drying, which products are suitable for drying, and how to make the product marketable. The loans will be distributed through the village development committee or the municipality.

Project 4: Rapid survey of air-borne carcinogenic compounds / polycyclic aromatic hydrocarbons in the air, Kathmandu

Proposed by: Devkota (2000)

Executive and promoting organisation: Ministry of Transport and Ministry of Population and Environment

Implementing organisation: Local NGOs and other private firms working in related fields

Duration: 6 months

Location: Kathmandu Valley

Cost: The study proposed will cost about US$ 10,000. The money will be used in sampling, chemicals, analysis, dissemination, and labour.

Rationale: Risk of ambient suspended particulate matter to local communities needs to be considered at various levels, particularly at planning and policy levels. Chemically such particulate matter may contain carcinogenic, mutagenic, or teratogenic elements or compounds such as trace metals, polycyclic aromatic hydrocarbons, and others. As there is a long latent period for carcinogenic symptoms in humans, for people of advanced age it may not be possible to distinguish the causative factors. However, the country will have to allocate a huge amount of money to reverse the situation. Since all combustion processes produce poly aromatic hydrocarbons (PAH), major anthropogenic sources of PAHs include heating (coal, oil, and wood), refuse burning, coal production, industrial processes, and motor vehicles (Bender et al. 1989).

Objective: To identify the concentration of major PAH compounds like benzo-a-pyrene in ambient suspended particulate matter

Methodology: This particular study will cover particulate phase PAHs only. High volume samplers will be used to collect ambient particulate matter. Materials collected on Whatman filter paper will be analysed by gas chromatography using standard samples of carcinogenic compounds.

References

ADB (1999) *Ambient Air Quality Monitoring of Kathmandu Valley*, ADB TA 2847. Kathmandu: MoPE/ ADB

Adhikari, A.P. (1998) *Urban and Environmental Planning in Nepal*. Kathmandu: IUCN

Adhikari, D.P. (1997) *Energy and Environmental Implications of Alternative Transport Options: The Case of Kathmandu Nepal*, M Eng. Thesis. Bangkok: Asian Institute of Technology

Boden, T. A.; Marland, G.; Andres, R. J. (1995) *Estimates of Global, Regional and National Annual CO_2 Emission from Fossil Fuel Burning. Hydraulic Cement Production and Gas Floss 1950-1992*. Oak Ridge: USDOE, Oak Ridge National Laboratory, Carbon Dioxide Information Analysis Center

CBS (1994) *A Compendium on the Environmental Statistics of Nepal: Issues and Facts*. Kathmandu: CBS

CBS (1998) *A Compendium on Environment Statistics 1998 Nepal*. Kathmandu: CBS

CBS (1999) *Statistical Year Book of Nepal*. Kathmandu: CBS

Devkota, S..R (1992) *Energy Utilization and Air Pollution in the Kathmandu Valley Nepal*, M.Sc. Thesis. Bangkok: Asian Institute of Technology

Devkota S.R. (1993) *Ambient Air Quality Monitoring in Kathmandu*, Project Report of Kathmandu Valley. Kathmandu: Vehicular Emission Control Project (UNDP/ 92-034)

Devkota, S.R. (1998) 'Environment Management in Nepal: Managing the Unmanageable'. In *Ecological Economics,* 28: 31-40

Devkota, S.R. (2000) Rapid survey of air-borne carcinogenic compounds/polycyclic aromatic hydrocarbons in Kathmandu air, unpublished report submitted to EPC

DHM (1999) *Information on TSP Concentrations in the Kathmandu Valley* (unpublished document). Kathmandu: DHM

DoHS (1997) *DoHS Annual Report 1995/96*. Kathmandu: DoHS

DoHS (1998) *DoHS Annual Report 1996/97*. Kathmandu: DoHS

DoHS (1999) *DoHS Annual Report 1998/99*. Kathmandu: Ministry of Health Services

DoR (1998*) Nepal Road Statistics NRS – 1998*. Kathmandu: Ministry of Works and Transport, DoR

ENPHO (1993) *A Survey of Brick Industries in Kathmandu Valley*. Kathmandu: ENPHO

ENPHO (1993) *Air Quality Assessment in Kathmandu City*. Kathmandu: ENPHO

ENPHO (1999) *A Report on Study on Reduction of Pollution and Waste in the Himal Cement Company Limited, Kathmandu, Nepal*. Kathmandu: ENPHO

Hall, C.A.S.; Uhlig, J. (1991) 'Refining Estimates of Carbon Released from Land Use Change'. In *Journal of Forest Research***,** 21: 118-131

IUCN (1991) *Sources of Industrial Pollution in Nepal, A National Survey*. Kathmandu: NPC, National Conservation Strategy Implementation Project

IUCN (1992) *Environmental Pollution in Nepal, A Review of Studies*. Kathmandu: NPC, National Conservation Strategy Implementation Project

Kunwar, U.K. (1999) *Ambient Air, Surface Water and Ground Water Quality Standards for Kathmandu Valley*, Institutional Strengthening of MoPE (TA No. 2847-NEP), unpublished reported submitted to MoPE

LEADERS (1998) *A Citizen Report on Air Pollution in Kathmandu Valley: Children's Health at Risk*. Kathmandu: Leaders Nepal

LEADERS (1999) *A Comparative Study of Air Pollution in Three Major Cities of Nepal*. Kathmandu: Leaders Nepal

Malla, S. (1993) *Urban Energy Use and Environment Management: The Case of Kathmandu Valley*, M. Eng. Thesis. Bangkok: Asian Institute of Technology

Manandhar, A. (2000) *Status of Cleaner Production (CP) in Nepal* (unpublished document). Kathmandu: MoI, Environment Sector Programme Support (ESPS)

MoA (1999) *Statistical Information on Nepalese Agriculture 1998/1999*. Kathmandu: MoA, ASD

MoF (1998) *Economic Survey 1997/98*. Kathmandu: MoF

MoPE/HMG (1998) *State of the Environment Nepal*. Kathmandu: MoPE

NBSM (1999) *Nepal Country Program for the Phase out of Ozone Depleting Substances*. Kathmandu: NBSM/UNEP-EAP.AP

NESS (1995) *Research on Enviornmental Pollution and Management.* Kathmandu: NESS

NESS (1999) *Ambient Air Quality Monitoring of Kathmandu Valley,*ADB TA 2847-NEP Project, unpublished report submitted to MoPE

Niraula, B.P (1998) 'Health'. In *A Compendium On Environment Statistics 1998 Nepal*. Kathmandu: NPC/CBS

Pandey, M.; Basnet, B. (1987) *Chronic Bronchitis and Cor Pulmonale in Nepal, A Scientific Epidemiological Study Monograph*. Kathmandu: Mrigendra Medical Trust

SEAMCAP (2000) *State of Environment Dataset Report Nepal: Strengthening Environment Assessment and Monitoring Capabilities in Nepal*, unpublished project report. Kathmandu: UNEP/ MoPE/ ICIMOD

Shah, J.; Nagpal, T. (eds) (1997) *Urban Air Quality Management Strategy in Asia, Kathmandu Valley Report*, World Bank Technical Paper No. 378. Kathmandu: World Bank

Shrestha, R.M.; Malla, S. (1996) 'Air Pollution from Energy Uses in a Developing Country City: The Case of Kathmandu Valley Nepal'. In *Energy* 21: 785-794

Sharma, T.; Upadhyaya, N.P. (1995) *Lead pollution in Kathmandu: Atmosphere and Street Dust*, Kathmandu Series and Research on Environment Pollution and Management. Kathmandu: NESS

URBAIR (1996) *Urban Air Quality Management Strategy in Asia*. *Kathmandu Valley Report*, World Bank Technical Paper No. 378 (preliminary version). Kathmandu: World Bank

US – EPA (1991) *Compilation of Air Pollution Emission Factors (AP-42), Volume II: Mobile Source (Supplement A)*. Research Triangle Park (North Carolina): USEPA, Office of Air Quality Planning and Standards, Emission Inventory Branch

WECS (1996) *Energy Synopsis Report 1994/95, Nepal.* Kathmandu: WECS

WECS (1997) *WECS Bulletin,* 8(1)

WECS (1999) *WECS Bulletin*,10(1 and 2)

Part IV
Conclusions and Recommendations

4.1 Conclusions

Nepal's five fundamental environmental issues are identified as forests, soil, solid waste, water, and air. These issues are interrelated. This part summarises the existing condition of these environmental components, points out emerging issues and future challenges, and suggests recommendations.

4.1.1 Forest depletion

The forest resources of Nepal are facing the great challenge of conservation. Rapid deforestation has resulted in several environmental consequences: increased landslides, soil erosion, floods, soil fertility depletion, migration of people, and diminishing crop yields.

- The forest area of Nepal has declined sharply from nearly 38% in 1978/79 to 29% in 1994. Between 1978/79 and 1994, the rate of deforestation in the country was 1.7% per year. It was 2.3% and 1.3% in the Hills and the Terai respectively. The growing stock of sal (*Shorea robusta*) declined from 101 to 72 m^3/ha in the Terai forests. Likewise other hardwood forests in the Terai declined in growing stock from 76 to 58 m^3/ha. The forest is disappearing because of: (i) excessive use of fuelwood, which makes up 78% of total fuel consumption; (ii) intense pressure from livestock grazing on the forestlands - the grazing area since 1984 has remained constant at 1,757,000 hectares but the large livestock population increased from 14.9 million in 1984 to 17.6 million in 1997; (iii) wrongly designed government forest policies (such as the Private Forest Nationalisation Act [1957] and the Land Tax Act [1977]) that allowed local people uncontrolled access without responsibility to both public and private forests in their areas; and (iv) increase of cultivated area (38.5% to 49.8% from 1963-1979) in the Terai through forest encroachment.
- The forest area in 1994 was 29% of the country's total area. The Siwaliks contained about 70% of the Terai forest coverage, the largest forest area in the country. The major national demand for timber and fuelwood is met from the Terai forests because they are the most productive and accessible.
  - During 1978/79-1994, the shrub area increased by 126% but the forest area decreased by 24%. The Far West region had the highest rate of forest degradation at 31%.
- The major impacts of forest depletion are: (i) a decline of the forest structure from a growing stock of 522 million m^3 over bark up to 10 cm top diameter in 1985 to 387.5 million m^3 in 1999; (ii) a threat to the country's 47 endemic plant and animal species, which comprise 3.8% and 2.3% of the world's threatened species; (iii) occurrence of landslides, soil erosion, and floods – affecting human lives and property; (iv) emission of an estimated 7.77 million tonnes of CO_2 into the atmosphere with an annual deforestation rate of 26,602 hectares; and (v) a decline in total accessible forest from 5.8 million hectares in 1985 to 4.6 million hectares in 1994.
- Policy measures undertaken to conserve forest resources include: (i) the National Forestry Plan (1976), (ii) the Master Plan for the Forestry Sector (1989 - 2010), (iii) the Forest Protection Act (1967), (iv) the National Parks and Wildlife Conservation Act (1973), (v) the Forestry Act (1992), (vi) the EIA guidelines for the forestry sector 1995, and (vii) the Plant Protection Act (1997).
- The forest sector has suffered from the following shortcomings: (i) lack of data about the total forest area contributed to other sectors, particularly for road construction, (ii) no information on tree coverage outside the public forests, and (iii) lack of information on endangered plant species.
- Suggestions for forest resource development are: (i) classification of forests; (ii) expansion of forest management through community participation; (iii) conservation of the Siwalik forests and their ecosystem; (iv) more extensive planting of trees; (v) encouraging the private sector in the use and management of forests; (vi) more programmes to generate public awareness about forest conservation; and (vii) more emphasis on forest research.

4.1.2 Soil degradation

- Nepal's mountains are characterised by steep and unstable slopes that are inherently prone to landslides and soil erosion. Intensive monsoon rainfall that occurs within a short span of time is an important factor, as it causes heavy soil erosion in the mountains. Different forms of mass wasting, such as landslides, slumps, rockfalls, and river cuttings, are responsible for sedimentation in the valleys, plains, and river basins. Rapid growth of human and livestock populations is putting severe pressure on Nepal's soil resources.
  - Development works, particularly the construction of mountain roads without adequate conservation measures, have also contributed to landslides and soil erosion.
  - Studies have shown that about 60–80% of the total annual soil loss from cultivated terraces occurs during the early storms of the pre-monsoon season when the vegetative cover is at a minimum and the fields are ploughed for planting.
  - Imbalanced application of chemical fertilisers on farmlands has also caused soil fertility to decline through changes in soil structure and acidification.
  - The Siwalik hills, degraded grasslands, and shifting cultivation areas are generally more vulnerable to heavy soil erosion.
  - The red soils of the Middle Mountains are prone to sheet and gully erosion because of low infiltration rates and a tendency towards surface crusting. Likewise, pine forest areas are much more vulnerable to soil erosion than broadleaved forests.
- The country has suffered from a stagnant trend in production of major food crops, and this has been attributed to a decline in soil fertility. Once a rice exporting country, Nepal now imports rice. Due to a one-way flow of nutrients from forests to agricultural land, the fertility of forest soil is continuously declining. Landslides have resulted in the loss of lives and damage to property and development infrastructure.
- Soil degradation is perhaps the greatest impediment to development in Nepal. To address this problem, a separate government department — the Department of Soil Conservation and Watershed Management (DSCWM) — was established in 1974.
  - DSCWM's programmes are directed by the Forestry Master Plan which emphasises integrated soil conservation through people's participation at the sub-watershed level.
  - Community forestry programmes have proved to be a successful policy initiative with a direct bearing on addressing soil degradation problems.
  - Formulation of the Agricultural Perspective Plan and signing of the United Nation's Convention to Combat Desertification are other commitments shown by the government to soil conservation.
- Recommendations for soil conservation include: (i) formulation and implementation of a policy on sustainable use of land according to its capacity; (ii) promotion of the synergistic combination of organic and inorganic fertilisers through intensive extension and training of farmers; (iii) liming; (iv) efficient management of watersheds using integrated soil fertility management systems, agro-forestry, horticulture, and so on; (v) tying up income generation activities with programmes that focus on rehabilitating degraded lands; (vi) establishment of a common forum for all organisations studying different aspects of soil degradation; and (vii) conducting long-term studies on different dimensions of soil degradation in the different ecological regions of Nepal.

4.1.3 Solid waste management

Solid waste in Nepal is essentially an urban phenomenon. Fifteen per cent of the population live in urban areas.

- Rapid and haphazard urban growth has exerted tremendous pressure on the urban environment as well as on the capacities of local government and people to manage it.

- Solid waste is the most visible environmental problem among many in urban areas.
- Heaps of garbage often litter the streets of Kathmandu and small dumping sites exist on river banks and in other public places in all municipal areas.
- The composition of urban wastes has changed drastically from traditional organic materials to plastics, paper, and glass.

• Households are the main sources of solid waste, followed by agricultural and industrial wastes.
  - The estimated per capita waste generation in cities varies from 0.25 to 0.5 kg per day.
  - Based on the present urban growth rate and per capita waste generation, by 1999 all 58 municipal areas together will generate approximately 426,486 tonnes of waste, accounting for 83% of all solid waste generated in the country. The city of Kathmandu alone accounts for slightly less than one-third of the total waste generation.
  - Although the share of plastics in urban waste is increasing, two-thirds of the waste is still organic. In Bhaktapur, for instance, organic materials constituted 89% and plastic only 2% of its total waste.
  - Most urban residents dump their waste in public places or at fixed sites along the streets. Only 18% of the urban population are served by the municipal solid waste management service (MSWMS). Less than one-fifth of the urban population has their waste collected by a garbage collector.
  - Hazardous wastes in the country include obsolete pesticides, batteries, and other wastes from hospitals and industry.
  - Hospitals generate about 500 tonnes of hazardous waste per year, with only a small proportion of it burned in ordinary kilns.
  - About 67 tonnes of hazardous obsolete pesticides (such as BHC, aldrin, and endosulfan) are generated annually, with most of them stockpiled in unsafe conditions at various locations in the country. About 38% of farmers bury or burn old/unused pesticides.
  - Nepal consumes approximately 45 million dry cell batteries per year. The total amount of dry cells disposed of per year is about 225 tonnes. In addition, about 10 tonnes per year of hazardous waste is generated from battery manufacturing factories in the country.

• There is no cohesive plan for solid waste management.
  - The government started its involvement in waste management on a project basis in 1980 in the city of Kathmandu. The success story of modern waste management ended when the project terminated in 1993, and the waste management group was affiliated as a small unit with the government's local development ministry.
  - In 1996, attempts were made to prepare policies on solid waste management, but these were never implemented because of lack of plans and programmes.
  - The Local Self-Governance Act (1999) has made municipalities totally responsible for solid waste management. However, because of lack of adequate financial resources and technical expertise, most municipalities are unable to manage the waste in an efficient manner.
  - No landfill site for waste is provided to municipalities except for Kathmandu city. The Kathmandu landfill site is often a cause of dispute.
  - Municipal waste is managed by local people, NGOs, and clubs on a piecemeal basis. They are also involved in recycling waste.
  - The government of Nepal has neither defined hazardous waste nor issued any standards for its disposal.

• The volume of solid waste is still small. But the poor government response and weakness of institutions at the municipal level have resulted in improper management of waste.

• Much effort is required to encourage municipal communities to take more effective action, such as door-to-door collection and composting, involving the private sector, and mobilising public participation.

4.1.4 Water quality

Water is the largest natural resource in Nepal with around 224 billion m^3 of renewable surface water per year.

- Intense pressure on water resources is found in the country because of the increasing demand for water for drinking, industries, irrigation, and so on, and use of rivers for disposal of liquid and solid waste.
  - About 66% of the total population in 1999 had access to piped drinking water. The demand for drinking water was found to be very high in large cities like Kathmandu where the total supply of drinking water has met only 79% of the total urban demand. Both surface and groundwater in the valley have been exploited to a maximum extent.
  - Water quality has deteriorated, particularly in the large urban areas of Nepal. Nearly all domestic waste water and industrial wastes are discharged directly into rivers without treatment. An average of 20,846 kg BOD/day of domestic waste water was found to have been discharged into the Bagmati River, which constituted 42% of the total BOD load produced in the valley. The total industrial BOD load discharged directly into the river was 3,151 kg/day. Forty per cent of the total industrial units in the country were reported to be water-polluting industries.
  - Summer rainfall has caused increased turbidity and nutrients in river water.
  - Use of agricultural pesticides has greatly affected the quality of water in streams and ponds.
  - Decline in forest cover has reduced the water recharge capacity of groundwater sources.
  - The increase in the built-up area of major urban centres has lowered the recharge capacity of groundwater sources.
  - The water in the Pokhara Valley lakes suffers from eutrophic conditions.
  - Quarrying of sand and stone from rivers in and around major urban areas has intensified.
  - Together, these activities are responsible for increasing the turbidity of river water, the declining abundance and type of fauna, and diminishing of urban aesthetic values.
- The average estimated, annual surface run-off and the estimated groundwater reserves of the country are 224 and 12 billion m^3 respectively. In 1998, it was estimated that two-thirds of the water demand were fulfilled. The current groundwater withdrawal is about 0.52 billion m^3 per year.
  - In 1998, the total annual withdrawal was 7.4% (16.7 billion m^3/year), of which 96.3% was used for agriculture, 3.4% for domestic purposes, and the rest for industry.
- The incidence of water-borne diseases among the general population is increasing in Nepal.
  - During 1996, the incidence of diarrhoea among children below five years of age was 131 per thousand children. The mortality rate per 1,000 children under five years of age due to diarrhoea was 0.34.
  - Cleaning vegetables with polluted river water for marketing in major urban areas has an adverse effect on the health of the general population.
- The following are suggestions to improve the condition of water: (i) managing waste disposal and controlling open defaecation, (ii) maintaining drinking water pipelines and sewer pipelines, (iii) providing potable water to the general population, (iv) setting up a lead agency for coordinating water-related organisations and for water quality control, management, and planning, (v) introducing a water quality monitoring programme, (vi) providing appropriate techniques for rainwater harvesting, (vii) conducting effective awareness programmes for conserving water quality and quantity in all parts of the country, (viii) adopting on-site treatment systems for recycling domestic grey water, and (ix) introducing treatment plants at the local community level.

4.1.5 Air pollution

Air pollution is a recent phenomenon in Nepal and is primarily related to the living conditions of the people, physical environment, and human activities.

- Air pollution in Nepal has risen.
  - The expansion of transportation in the country is the most important factor causing air pollution. The number of vehicles increased from 75,159 in 1988 to 220,000 in 1998. The consumption of petrol rose from 31,061,000 litres in 1993 to 46,939,000 litres in 1997, while the consumption of diesel increased from 195,689,000 litres in 1993 to 302,063,000 litres in 1997. The Bagmati zone of Nepal, including the Kathmandu Valley, has the highest traffic density of 51 vehicles per km of road.
  - Deforestation has released carbon at an estimated rate of 7,768,000 tonnes per annum.
  - Seventy-four per cent of total industries contributed to air pollution, of which 33% were in the Kathmandu Valley.
  - Dust pollution is a common problem.
- The total energy demand was estimated to be 277 million gigajoules (GJ) in 1993, with an average increase of 2.4% per annum.
  - Out of the total energy consumption, 91% was consumed by the residential sector and the remaining 9% by other sectors.
  - About 90% of the energy demands were met from traditional sources such as fuelwood, agricultural residues, and animal waste. The shares of petrol, coal, and electricity in the total consumption were estimated to be 8, 2, and 1% respectively.
  - The average total suspended particulates (TSP) value recorded at one site in the Kathmandu Valley in 1996 was 200 with a maximum of 315 in April and minimum of 81 $\mu g/m^3$ in August. The suspended particulate matter and PM-10 level in the ambient air in the Kathmandu Valley were above the WHO guidelines, whereas the levels of other pollutants such as SO_x, NO_x, and CO were within the WHO standards. The PM-10 is comprised mostly of hydrocarbons emitted by vehicles.
  - The estimated amounts of greenhouse gases (GHGs) such as CO_2, CH_4, and NO_x emitted into the air were: 3.96×10^6 - 15.45×10^7 tons/year of CO_2 because of deforestation and 354,000 tonnes of CO_2 caused by combustion of fossil fuels; 72,000 tonnes of carbon and 1,790 tonnes of NO_x per year from the consumption of petroleum products; and 1.2 million tonnes/yr of CH_4 mainly from agriculture.
  - A total of 29.06 and 23.04 tonnes respectively of the ozone depleting substances (ODS) CFC-12 and HCFC–22, were estimated to have been released into the air in 1996.
  - Electric vehicles and unleaded petrol were introduced into Nepal in 1999.
- The main impact of air pollution is found to be on public health. In Kathmandu, hospital records indicate that pneumonia, upper respiratory tract infection (URTI), acute respiratory infection (ARI), asthma, bronchitis, chest infections, lower respiratory tract infection (LRTI), whooping cough, and pneumonia are major diseases.
  - Acute respiratory infection (ARI) is considered to be among the top five diseases. About 30% of deaths of children of five years and below are from ARI.
- Nepal has attempted to reduce air pollution through adopting several measures. The Nepal Vehicle Mass Emission Standard (NVMES) 1999, similar to the EURO-1 standard, is a major step for reducing vehicular emissions, mainly in three tourist areas: Kathmandu Valley, Pokhara, and Lumbini. Implementation of the acts related to air pollution is an urgent necessity. The monitoring of air pollution has been carried out through a vehicle exhaust emission test since 1994. Environmental Impact Assessment (EIA), which aims at sustainable development of environmental activities, should be carried out seriously wherever and whenever feasible before issuing a license to any industry. Studies should be carried out on various aspects of air pollution, covering major places in other parts of the country, to produce regular time series data on air quality.

4.2.1 Emerging issues

In the foregoing section, five fundamental environmental issues are summarised.

- In addition, there are other issues that are emerging in the country such as haphazard urbanisation, glacial lake outburst floods (GLOF), food security, noise pollution, and population growth and migration (rural-rural and rural-urban).
- Further, there are issues that have indirect impact on the sustainable development of the environmental components. They include inadequate access to existing facilities such as roads, health, schools, markets, banks, veterinary services, electricity, and so on. These are the social and economic driving forces for the environmental conservation of the country.

4.2.2 Future challenges

Nepal is now facing several challenges and will likely face more on the road ahead if serious measures to combat existing challenges are not undertaken. The challenges are listed below.

- Environmental challenges: control of land degradation; maintenance of ecosystems through balanced land-use planning; control of air pollution in large urban areas; management of hazardous wastes; supply of adequate potable drinking water; and conservation of biodiversity
- Socioeconomic challenges: creation of employment generating activities; alternative energy sources to fuelwood; food security; rural to rural and rural to urban population migration; and water-borne, water-washed, and acute and chronic respiratory diseases

4.2.3 Recommendations

The recommendations given here are general and can be applied to sustainable development of the environment. Specific recommendations have already been given for each of the key issues.

- A fundamental problem in planning and sustainable development of environmental components is the lack of adequate data. There is a problem of data availability. When available, data are either poor in quality, do not match between years or places, or are not reliable. A strong database covering a large part of the country (spatial) and for different years and seasons (temporal) needs to be established. Together with this, well-defined database management is a must. Metadata containing the description of the data set of every component by source, area, time (year and month), type, and amount should be recorded. Data should be shared among departments and within organisations and with the general public. This would help to control data duplication among organisations of a similar type.
- Because of the poor monitoring system, programmes aimed at mitigating the deteriorating conditions of the environment have not been successful. Existing monitoring systems in government organisations tracking activities in the right direction and with an output-orientation need to be made more effective; this can be achieved with dedication and commitment. Reward and punishment systems in government organisations should be applied sincerely and effectively.
- Integrated action plans and programmes need to be made including all environment-related activities, for instance, forests, soil, water, solid waste, and air, and other components related to the environment such as roads, settlements, and land use. In making plans and programmes, these components need to be put together so that the deteriorating condition of the environment can be mitigated.
- EIA, which seeks sustainable development of environmental activities, should be implemented seriously and honestly in any development activity.
- Environmental development programmes should be clearly defined in terms of short-term and long-term planning policy measures.
- Coordination among different line agencies is one of the essential components for making the programme successful.
- The above suggestions for policy measures will not be effective if the government's attempts to implement them are not serious, sincere, and determined.