

Forestry

Principles and Applications

Antony Joseph Raj

S. B. Lal



SCIENTIFIC
PUBLISHERS

FORESTRY

PRINCIPLES AND APPLICATIONS

Editors & Authors

ANTONY JOSEPH RAJ Ph.D.

Associate Professor (Forestry)
Department of Land Resources Management and Environmental Protection
Mekelle University, Ethiopia
& Associate Dean (On Leave)
College of Forestry and Environment
Sam Higginbottom Institute of Agriculture, Technology and Sciences
(Formerly Allahabad Agricultural Institute) Deemed University
Allahabad, Uttar Pradesh, India

S.B. LAL Ph.D.

Pro-Vice Chancellor and Dean
College of Forestry & Environment of SHIATS-Deemed University
(Formerly Allahabad Agricultural Institute)
Allahabad

Published by:

Scientific Publishers (India)
5 A, New Pali Road, P.O. Box 91
Jodhpur 342 001 (India)

E-mail: info@scientificpub.com
Website: www.scientificpub.com

Branch Office

Scientific Publishers (India)
4806/24, Ansari Road, Daryaganj
New Delhi - 110 002 (India)

Print: 2015

All rights reserved. No part of this publication or the information contained herein may be reproduced, adapted, abridged, translated, stored in a retrieval system, computer system, photographic or other systems or transmitted in any form or by any means, electronic, mechanical, by photocopying, recording or otherwise, without written prior permission from the authors and the publishers.

Disclaimer: Whereas every effort has been made to avoid errors and omissions, this publication is being sold on the understanding that neither the author nor the publishers nor the printers would be liable in any manner to any person either for an error or for an omission in this publication, or for any action to be taken on the basis of this work. Any inadvertent discrepancy noted may be brought to the attention of the publishers, for rectifying it in future editions, if published.

ISBN: 978-81-7233-810-7

eISBN: 978-93-86237-74-3

© 2013, Antony Joseph Raj & S.B. Lal

Printed in India

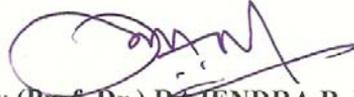
FOREWORD

Forests are a critical link in the transition to a green economy – one that promotes sustainable development and poverty eradication as we move towards a low carbon and more equitable future. Forests supply wood, fibre, fuelwood and non-wood forest products for industrial and non-industrial uses. Biologically-rich forest ecosystems provide a wide range of provisioning, regulating, cultural and supporting services for human well-being collectively known as ecosystem services.

The sustainability of forest ecosystems depends on sustained management, efficient utilization and effective protection measures against deforestation and forest degradation. The role of ecosystem services are equally important for sustaining livelihoods and maintaining environmental conditions. The benefits of reducing deforestation for climate change alone is estimated to be in the trillions. Yet despite these huge ecological, economical, social and health benefits, forest are still being destroyed at an alarming rate of 13 million hectares annually for limited and short-term gains.

This comprehensive textbook “Forestry: Principles and Applications” by Dr. Antony Joseph Raj and Prof. (Dr.) S.B. Lal will provide a significant contribution in university and college lecture halls. This book forms a comprehensive and thoroughly up-to-date text on forestry and a detailed exploration of specific and modern technologies in the field of forestry. By bringing current knowledge on forestry and natural resources together in one place, this book will advance our ability to manage the remaining forest resources and safeguard their continuing contribution to human beings. It is my wish that students, teachers, scientists and professional foresters will find the information on this textbook valuable. In future, the acquired knowledge will be helpful not only for the development of sustainable forest management in India but also as an input to policy formulation with respect to Indian forests.

I welcome this latest book which is first of its kind in India as an editorial textbook on forestry. I believe this book, with its high standard, will serve the students for the preparation of competitive exams like UPSC Civil Service Exam, UPSC Indian Forest Service Exam, ICAR Scientists/NET Exam, etc. I would like to congratulate the authors, Dr. Antony Joseph Raj and Prof. (Dr.) S.B. Lal, for their meticulous and hard work in bringing this important textbook into being.



[Rev.(Prof. Dr.) RAJENDRA B. LAL]

Vice-Chancellor
Sam Higginbottom Institute of Agriculture, Technology and Sciences
(Formerly Allahabad Agricultural Institute) Deemed University
Allahabad, Uttar Pradesh, India

September, 2012

PREFACE

The material resources and life supporting functions provided by forest lands are particularly important in developing countries where some people still rely on them directly as sources of food, fodder, fuelwood, medicine, shelter, building materials and as centers of certain cultural practices. In recent years, the capability of forests to mitigate climate change, provide renewable products and energy, maintain biological diversity, protect land and water resources, provide recreation facilities, improve air quality, help alleviate poverty and contribute to developing a greener economy have received increasing attention. But at the same time, these benefits are threatened by land and forest degradation, global warming and extreme weather events. An ever increasing population places enormous demands on the forest and land resources. Carbon sequestration in forest ecosystems has become an important issue both in the political discussion about abrupt climate change and forest ecosystem research.

National Forest Policy 1988 mandates expanding forest cover from 23.81 to 33 per cent of India's territory and the overarching objective of the Green India Mission is to increase forest and tree cover in 5 million hectares and improve quality of forest cover in another 5 million hectares. There is a challenge to devise comprehensive work plan for sustainable development of forests in India in next twenty years. To cope with challenging task, forest managers have to integrate modern knowledge resulting from all the disciplines of forestry into the management plans. We are expected to shift towards modern trends and latest concepts to upgrade the knowledge and skills in forestry. This book is the first in the forestry text book series to synthesize information on relevant processes, factors and causes of carbon turnover in forest ecosystem and the technical and economic potential of carbon sequestration. Accordingly the book is able to fill an important gap between the needs of global forest and environmental policies and local forest management. In fact, the book makes a valuable contribution to the knowledge of students, academicians, research scientists, modern foresters and policy makers, which will, in turn, guide efforts to manage the remaining forests and new forests in the millennia to come.

There are many forestry textbooks available in India which provide a more balanced account of subjects. The classic examples are textbooks authored by pioneers like P.K.R. Nair, D.N. Tewari, L.S. Khanna, A.P. Dwivedi, A.N. Chaturvedi, Tribhawan Mehta, Ram Prakash, S.S. Negi, R.K. Luna and others. In many aspects, the topics and structure of this

textbook is highly meritorious and unique. All the individual chapters are contributed by Subject Matter Specialists/ Experts of high repute carefully selected based on their experience and practical knowledge from throughout India and abroad (few chapters).

In fact, the book collates valuable knowledge on forestry and natural resources which will be useful to students for their regular semester exams, University entrance examinations for admission to M.Sc. & Ph.D. programmes, preparation of competitive exams like Civil Service Exams (UPSC), Indian Forestry Service (UPSC), ICAR-ARS Scientist Exam, ICFRE Forestry Scientist Exams, NET Exam, State Public Service Commission Exams, etc. This compilation will be most useful for the people in Universities and Colleges, Research Institutions dealing with biological sciences, agricultural sciences and forestry sciences and Forest Departments of all the States of India. The general subject matters available in the book will be beneficial to persons from forestry, agriculture and natural resources field in other countries.

This textbook will contribute significantly to academic teaching and scientific research. Additional information or suggestions that will improve this book are invited from experts. Finally we would like to express our deep gratitude to all our friends and well wishers for providing numerous comments and suggestions for enhancing the quality of the book.

ANTONY JOSEPH RAJ
S.B. LAL

September 2012

LIST OF CONTRIBUTORS

Prof. S.B. Lal

Pro-Vice Chancellor and Dean, College of Forestry and Environment, SHIATS Deemed University, (Formerly Allahabad Agricultural Institute), Allahabad, Uttar Pradesh

Shri. K.C.A. Arun Prasad, IFS

Director & Dy. CWLW (Keoladeo National Park) in Rajasthan Forest Department (Earlier) and Presently on Deputation as Associate Professor, Indira Gandhi National Forest Academy, Dehradun, Uttarakhand

Shri. L.Chandrasekar, IFS

Divisional Forest Officer, Kerala Forest Department (Earlier) and Presently on Deputation in Central Academy for State Forest Service, Coimbatore, Tamil Nadu

Shri. Rajesh G. Nair, IFS

Additional Chief Executive, Chilika Development Authority, Bhubaneswar, Odisha

Shri. M. Senthil Kumar, IFS

Divisional Forest Officer, Dharmapuri Division, Dharmapuri, Tamil Nadu

Shri. N. Satheesh, IFS

Divisional Forest Officer, Satyamangalam Division, Sathyamangalam, Tamil Nadu

Prof. M. Paramathma

Executive Director, National Oilseeds and Vegetable Oil Development (NOVOD) Board, Ministry of Agriculture, Department of Agriculture and Cooperation, Government of India, Gurgaon, Haryana

Prof. S. Chellamuthu

Director, Water Technology Centre, Tamil Nadu Agricultural University, Coimbatore, Tamil Nadu

Prof. N.B. Singh

Director of Extension Education, Dr.Y.S.Parmar University of Horticulture and Forestry, Nauni, Solan, Himachal Pradesh

Prof. S.T. Naik

Associate Director of Extension, University of Agricultural Sciences, Dharwad, Karnataka

Prof. C. Sekhar

Professor and Head, Department of Forest Resource Management, Forest College and Research Institute (FC&RI), Mettupalayam, Tamil Nadu

Prof. C.T. Ashok Kumar

Department of Entomology, college of agriculture, U.A.S., G.K.V.K., Bangalore, Karnataka

Dr. K. Sasikumar, IFS
Divisional Forest Officer,
North Tripura District,
Kumarghat, Tripura

Shri. Sanjayan Kumar, IFS
Deputy Director,
Periyar Tiger Reserve,
Kerala

Shri. R. Manikanda Ramanujam, IFS
Deputy Conservator of Forest
Wadsa Forest Division
Maharashtra

Shri. Bheemsingh Mohandaas, IFS
Assistant Conservator of Forest
(Working Plan),
J&K Forest Department,
Jammu and Kashmir

Shri. T. Mohan Raj, IFS
Assistant Conservator of Forest,
Tonk, Rajasthan

Dr. A.V. Santhoshkumar
Associate Professor & Head, Department of Tree
Physiology and Breeding, College of Forestry
Kerala Agricultural University, Thrissur,
Kerala

Dr. Munish Kumar
Associate Professor, Department of Soil
Conservation and Water Management/Forestry,
C.S. Azad University of Agriculture and
Technology, Kanpur, Uttar Pradesh

Dr. Sanjeev Thakur
Senior Scientist, Department of Tree
Improvement and Genetic Resources,
College of Forestry, Dr.Y.S.Parmar University
of Horticulture and Forestry,
Nauni, Solan, Himachal Pradesh

Dr. Ramakrishna Hegde
Associate Professor & Head, Department of
Silviculture and Agroforestry, College of
Forestry, Ponnampet (UAS, Bangalore),
Karnataka

Dr. K.T. Parthiban
Associate Professor (Forestry), Forest College
and Research Institute (FC&RI),
Mettupalayam, Tamil Nadu

Dr. P. Masilamani
Associate Professor (Seed Science
&Technology)
Agricultural Engineering College and Research
Institute, Kumulur, Tiruchirappalli,
Tamil Nadu

Dr. C. Buvaneswaran
Scientist, Division of Forestry, Land Use and
Climate Change, Institute of Forest Genetics and
Tree Breeding, Coimbatore,
Tamil Nadu

Dr. A. Venkatesh
Principal Scientist (Forestry), ICAR Research
Complex for NEH Region,
Umiam (Barapani), Meghalaya

Dr. Sharad Nema
Associate professor (Forestry) & Head, School
of Studies (Forestry & Wildlife), Bastar
University,
Jagdalpur, Chhattisgarh

Dr. J. Jayaprakash
Scientist, Central Soil and Water Conservation
Research and Training Institute (ICAR),
Dehradun

Mr. Etefa Guyassa
Head, Department of Land Resources
Management and Environmental Protection,
Mekelle University,
Mekelle, Ethiopia

Dr. P. Ratha Krishnan

Senior Scientist (Forestry),
Central Arid Zone Research Institute,
Jodhpur, Rajasthan

Shri. S. Gopakumar

Assistant Professor, Dept. of Forest
Management & Utilization, College of Forestry,
Kerala Agricultural University,
Thrissur, Kerala

Dr. S. Umesh Kanna

Assistant Professor (Forestry), Forest College
and Research Institute (FC&RI),
Mettupalayam, Tamil Nadu

Shri. Ashutosh Pandey

Oilseeds Division, National Oilseeds and
Vegetable Oil Development (NOVOD) Board,
Ministry of Agriculture, Department of
Agriculture and Cooperation,
Government of India, Gurgaon, Haryana

Shri. Jadegowda

Assistant Professor, College of Forestry,
Ponnampet (UAS, Bangalore),
Karnataka

Mrs. Smitha Rajesh

Department of Forestry,
Orissa University of Agriculture and
Technology,
Bhubaneswar, Odisha

Ms. S. Vennila

Forest College and Research Institute (FC&RI),
Mettupalayam,
Tamil Nadu

Dr. S. K. Uttam

Assistant Professor, Department of Soil
Conservation and Water Management/Forestry,
C.S. Azad University of Agricultural &
Technology, Kanpur, Uttar Pradesh

Dr. Manmohan J.R. Dobriyal

Head In-charge, Department of Forest Products
and Utilization, College of Horticulture and
Forestry, MPUAT,
Jhalawar, Rajasthan

Dr. Munesh Kumar

Assistant Professor, Department of Forestry,
HNB Garhwal University, Srinagar Garhwal,
Uttarakhand

Dr. Rainer W. Bussmann

William L. Brown Center,
Missouri Botanical Garden,
St. Louis, MO 63110, USA

Dr. A. Vidhyavathi

Assistant Professor, Department of Forest
Resource Management, Forest College and
Research Institute (FC&RI), Mettupalayam,
Tamil Nadu

Dr. Afaq Majid Wani

Assistant Professor, College of Forestry and
Environment, SHIATS Deemed University,
(Formerly Allahabad Agricultural Institute),
Allahabad, Uttar Pradesh

Shri. R. Ezhumalai

Scientist - Wood Science, Institute of Wood
Science and Technology (IWST),
Bangalore, Karnataka

CONTENTS

PART 1: NATURAL RESOURCES

Chapter 1	Soil Resources – <i>Munish Kumar</i>	1-25
	What is Soil? - Soil Components - Soils of India - Nutrient Cycling - Nutrient Cycling in Forest Ecosystem - Weathering - Soil Formation - Organic Matter - Carbon Nitrogen Ratio - Humus	
Chapter 2	Water Resources – <i>S. Chellamuthu</i>	26-37
	Introduction - Water Resources of India - Water Requirements of India - Water Resources Management in India - Conclusion	
Chapter 3	Forest Resources – <i>Antony Jospheh Raj & Afaq Majid Wani</i>	38-52
	Introduction - Forest Definition - Global Scenario of Forest Resources - Forest Profile of India - Chronological View of Indian Forestry - Forestry in Five Year Plans - Central Board of Forestry - National Forestry Action Programme	
Chapter 4	Wildlife Resources – <i>Sharad Nema</i>	53-72
	Wildlife Definition - Values of Wildlife - Zoogeographic Regions of World - Indian Fauna and their Distribution - IUCN Categories of Wild Animals - Endangered Wild Animals in India - Protected Areas	

PART 2: TREE AND FOREST

Chapter 5	Tree Growth and Forest – <i>P. Ratha Krishnan</i>	75-92
	Introduction - What is Forestry? - Branches of Forestry - Tree Structure and Growth - Classification of Forests - Direct and Indirect Benefits of Forests - Impact of Climatic Factors on Trees and Forest - Site Quality, Bioclimate and Microclimate of Forests - Stand Types - Natural and Artificial Regeneration - Rotation - Thinning	
Chapter 6	Forest Ecology – <i>Munesh Kumar, Etefa Guyassa & Antony Jospheh Raj</i>	93-104
	Introduction - Concepts of Ecology - Ecosystem - Forest Ecosystem - Succession - Vertical Structure - Forest Community Dynamics - Community Structure Characteristics - Methods of Studying Forest Communities - Competitive Exclusion Principle and Ecological Niche Concept	

Chapter 7	Biodiversity and Conservation Biology – <i>Munesh Kumar & Rainer W. Bussmann</i>	105-128
	Introduction - Convention on Biological Diversity - What is Biodiversity? - Types of Biodiversity - The Value of Biological Diversity - Threats to Biodiversity - Loss of Biodiversity - Biodiversity Hotspots - Population Diversity - Measurement of Biodiversity - Biodiversity Conservation Strategy - <i>In Situ</i> and <i>Ex Situ</i> Conservation - Indian Scenario of Biodiversity Conservation - Medicinal Plants Conservation	
Chapter 8	Dendrology – <i>S. Gopakumar</i>	129-147
	Introduction - History of Plant Classification - International Code of Botanical Nomenclature - Identification of Trees in a Tropical Forest Landscape - Botanical Spot Characters and Utilization Aspects of Selected Tree Families - Collection and Submission of Herbarium Specimens	
PART 3:		
SUSTAINABLE TIMBER PRODUCTION		
Chapter 9	Plantation Forestry – <i>Etefa Guyassa & Antony Josphe Raj</i>	151-163
	Introduction - History of Forest Plantations - Status of Global Planted Forests - Significance of Forest Plantations - Paradigm Shifts in Tropical Forest Plantations - Sustainability of Plantations - Planted Forest Management - Constraints in Plantation Forestry	
Chapter 10	Sustainable Forest Management – <i>Manikanda Ramanujam</i>	164-174
	Introduction - What is Forest Management? - Concept of Sustainable Forest Management - Concept of Sustainability - Components of Sustainable Forest Management - Criteria and Indicators of Sustainable Forest Management - Indian Initiatives for SFM - Challenges of Sustainable Forest Management - Constraints to Sustainable Forest Management - Forest Certification	
Chapter 11	Working Plan – <i>Bheemsingh Mohandaas</i>	175-187
	Introduction - Working Plan Code - Organization - Objective and Scope of Working Plan - Brief History - Contents of Working Plan - Preparation of Working Plan	
Chapter 12	Timber Measurements and Timber Inventory – <i>Antony Josphe Raj</i>	188-213
	Concept and Scope of Forest Mensuration - Tree Diameter Measurements - Tree Height Measurements - Tree Basal Area and Volume Measurements - Stem/ Log Volume Measurements - Stem Form - Timber Inventory - Point Sampling - Plot Sampling - Stand Measurements - Empirical Height Equations, Volume Equations and Volume Table	
Chapter 13	Forest Pest Management – <i>C.T. Ashok Kumar & Veeresh Kumar</i>	214-230
	Introduction - Natural Forest Pest Control - Silvicultural Control - Silvicultural Practices to reduce Insect Activity - Mechanical and Physical Control - Biological Control - Microbial Control - Chemical Control - Classification of Insect Pests - Conclusion	
Chapter 14	Forest Disease Management – <i>S.T. Naik</i>	231-255
	Introduction - Plant Disease - Nursery Diseases - Root Diseases - Heart Rots - Forest Disease Control: General Principles - Diseases of Teak, Sal, Shisham, Khair, Neem, Sandalwood, Casuarina, Eucalyptus and Bamboos	

- Chapter 15 Forest Fire Management – *K. Sasikumar* 256-268
 Introduction - Classification of Forest Fires - Fire Environment - Occurrence of Forest Fire, Its Behaviour and Dynamics - Forest Fire Monitoring in India - Damages caused by Forest Fires - Methods of Extinguishing Forest Fire - Method of Protection against Damage by Fire - Fire Terminologies
- Chapter 16 Problem Soils and Its Management – *S. K. Uttam* 269-280
 Introduction - Salt Affected/Saline Soils - Acidic Soils - Waterlogged Soils

**PART 4:
 FORESTRY CONCEPTS AND TECHNOLOGIES**

- Chapter 17 Tree Seed Technology – *P. Masilamani* 283-306
 Introduction - Seed Collection - Seed Extraction - Seed Drying - Seed Processing - Seed Dormancy - Pre-Sowing Seed Treatment - Seed Storage - Seed Testing- Conclusion
- Chapter 18 Forest Tree Improvement – *Sanjeev Thakur & N.B. Singh* 307-331
 Introduction - Elements of Tree Improvement Programme - Species and Provenance Trials - Mass Selection - Plus Tree Selection - Seed Orchards - Progeny Testing - Advance Generation Breeding - Genetic Engineering - Clonal Forestry - Achievements in Tree Improvement - Glossary of Terms
- Chapter 19 Wood Science and Technology – *R. Ezhumalai* 332-349
 Introduction - Tree Growth - What is Wood? - Wood Structure - Moisture Content of Wood - Wood Destroyers and Preservatives - Abnormal Wood and Wood Seasoning Defects
- Chapter 20 Clonal Forestry – *A.V. Santhoshkumar & Jiji Joseph* 350-358
 Introduction - Vegetative Propagation Methods in Forest Trees - Application of Vegetative Propagation in Forestry - Incorporation of Vegetative Propagation Techniques in Tree Breeding - Applications of Clonal Forestry
- Chapter 21 Wildlife Management – *K.C.A. Arun Prasad* 359-378
 Wildlife Management: Definition - Concept of Wildlife Management - What to Conserve? - How Protected? - Protected Area Planning - Ramsar Sites - World Cultural and Natural Heritage Sites - Biosphere Reserves - Tiger Reserves - Project Elephant - Habitat Management - Wildlife Census - Reintroducing Rare and Endangered Species - *Ex-Situ* Conservation
- Chapter 22 Forest Nursery Technology – *J. Jayaprakash, Rajkumar & A.C. Rathore* 379-396
 Introduction - What is Forest Nursery? - Significance of Forest Nursery - Classification of Forest Nurseries - Seedling Quality - Nursery Planning and Management - Nursery Site Selection - Collection of Planting Materials (Seeds, Wildlings and Cutting) - Bareroot Nursery - Container Nursery - Rooted Cuttings - Plant Propagation Structures

**PART 5:
 MODERN FORESTRY APPROACHES**

- Chapter 23 Economic Value of Forest Ecosystem – *C. Sekhar & A. Vidhyavathi* 399-419
 Introduction - Valuation of Natural Resources - Forest Ecosystem - Valuation of Forest Cover - Costs on Forestry - Valuation Techniques - Selected Economic

	Valuation Methods for Intangible Benefits - Distributional Concerns - Practical Difficulties of Economic Valuation of Forests	
Chapter 24	Application of Remote Sensing and GIS in Forestry – <i>N. Satheesh & T. Mohan Raj</i>	420-433
	Introduction - Remote Sensing Technology - Satellite Remote Sensing - Aerial Photography - Geographic Information System - Role of Remotes Sensing and GIS in Forestry - Forest Resource Monitoring - Forest Resource Estimation and Harvesting - Forest Resource Protection - Wild Animals Management & Others	
Chapter 25	Forest Based Industries – <i>K.T. Parthiban, S. Umesh Kanna & S. Vennila</i>	434-450
	Introduction - Major Forest Based Industries - Pulp and Paper Industries - Match Industries - Timber and Sawwood Industries - Plywood Industries - Particle Board Industries - Dendro Biomass Power Generation Industries - Oil and Biodiesel Industries - Value Addition Industries - Projected Wood Demand for Various Industries - Challenges of Forest Based Industries - Measures for Better Development of Forest Based Industries - Contract Farming Methods - Industrial Policy and Forest Based Industries - Conclusion	
Chapter 26	Modern Logging Methods – <i>Smitha Rajesh & Rajesh G. Nair</i>	451-467
	Introduction - Impacts of Logging on Forests - Methods of Logging - Logging Terminologies - Felling: Manual Felling and Mechanized Harvesting Systems - Felling Equipments (Chain Saw, Harvester, Feller Buncher) - Extraction Equipments (Skidder, Forwarder, Yarder, Helicopter) - Processing Equipments (Delimber, Chipper, Mulcher)-Loading Equipments (Log Loader) - Transport (Trucks and Trailers) - Logging Operations in Tropics - Reduced Impact Logging	
Chapter 27	Ecotourism – <i>Sanjayan Kumar</i>	468-481
	Introduction - Important Terminologies - What is Ecotourism? - Objectives of Ecotourism - Characteristics of Ecotourism - Principles of Ecotourism - Positive Impacts of Ecotourism - Threats to Ecotourism - Ecotourism in Protected Areas - Ecotourism Experiences from Parambikulam Tiger Reserve and Periyar Tiger Reserve in Kerala	
Chapter 28	Biofuel from Tree Borne Oilseeds – <i>M. Paramathma & Ashutosh Pandey</i>	482-500
	Introduction - Biofuels - Tree Borne Oilseeds - Characteristic Features of Potential Tree Borne Oilseeds - Status of Biofuel Production from TBOs in India - Biofuel Production Processes	

**PART 6:
PRACTICES FOR INCREASING FOREST COVER**

Chapter 29	Urban Forestry and Recreational Values – <i>Ramakrishna Hegde</i>	503-516
	Introduction - Increasing Impact of Process of Urbanization on Forests - Impact of Urban Growth on Indian Forest Resources - Urban Forestry in India - Benefits of Urban Forests - Establishment and Maintenance of Urban Forests	
Chapter 30	Agroforestry Practices – <i>Sharad Nema</i>	517-538
	Introduction - Concept and Definitions of Agroforestry - Importance and Impact of Agroforestry - Classification of Agroforestry Systems - Selection Criteria for Suitable Agroforestry Trees - Multipurpose Tree Species in Agroforestry - Soil Fertility Improvement in Agroforestry - Agroforestry Models for Different Agro-Climatic Zones of India - Tree-Crop Interactions under Agroforestry System - Future Prospects of Agroforestry	

Chapter 31	Social Forestry – <i>A. Venkatesh, K.P. Mohapatra, Manoj-Kumar, D.J. Rajkhowa & I.S.L. Mawphlang</i>	539-559
	Introduction - What is Social Forestry? - Classification of Social Forestry - Social Forestry Plantations in Specific Areas - Social Forestry Programmes in India - Support for Social Forestry - Different Social Forestry Schemes Implemented in India	
Chapter 32	Joint Forest Management (JFM) – <i>A. Venkatesh, Manoj Kumar, D.J. Rajkhowa & I.S.L. Mawphlang</i>	560-577
	Introduction - Origin and Evolution of JFM - JFM: Definition - Structures of JFM - Salient Features of JFM - Participatory Assessment and Planning - Role of NWFPS in JFM - Extent of JFM in India - Recent Policy Changes on JFM	
Chapter 33	Land Degradation and Wasteland Management – <i>S.B. Lal & Antony Jospeh Raj</i>	578-598
	Introduction - Land Degradation - Types of Land Degradation - Causes of Land Degradation - Assessment of Land Degradation - Effects of Land Degradation - Wastelands - Land Degradation in India - Historical Background of Wasteland Development in India - National Action Programme to Combat Desertification - Wasteland Management	

**PART 7:
SOCIAL VALUES AND BENEFITS**

Chapter 34	Forest Products Utilization – <i>Manmohan J.R. Dobriyal</i>	601-627
	Introduction - Lumber/ Timber - Composite Wood/ Engineered Wood - Veneers, Plywood and Other Composite Woods - Improved Wood/ Modified Wood - Fuelwood - Pulp and Paper Wood - Charcoal - Other Multiple Uses of Wood - Non-Wood Forest Products	
Chapter 35	Forest Policy and Legislations – <i>L. Chandrasekar</i>	628-647
	What is Policy? - The 1894 Forest Policy - The 1952 Forest Policy - The 1988 Forest Policy - Indian Forest Act 1927 - Wildlife (Protection) Act 1972 - Forest (Conservation) Act 1980 - Forest Rights Act 2006 - International Tropical Timber Agreement	
Chapter 36	Forest Tribes in India – <i>Jadegowda</i>	648-670
	Introduction - Concept and Definition of Forest Tribe - History of Forest Tribes in India - Classification of Indian Forest Tribes - Demography and Distribution of Forest Tribes in India - Tribal Economy - Policy related Tribal Development	
Chapter 37	Soil and Water Conservation – <i>Munish Kumar & S.K. Uttam</i>	671-687
	Soil Erosion - Water Erosion - Wind Erosion - Factors Affecting Soil Erosion - Soil and Water Conservation Methods - Control of Wind Erosion - Predicting Soil Erosion	

**PART 8:
FORESTS AND CLIMATE CHANGE**

Chapter 38	Climate Change and Forests – <i>C. Buvanewarar</i>	691-709
	Introduction - What is Climate Change? - Stern Review - Greenhouse Effect - Climate Change and Its Influences on Forests - Global Initiatives on Climate Change - Observed Climate Changes in India	

Chapter 39	Forest Carbon Sequestration and Carbon Trade – <i>Antony Joseph Raj</i>	710-737
	Overview on Global Carbon Cycle - Carbon Dioxide Emissions - Carbon Sequestration - Carbon Sequestration in Forest - Forest Carbon Accounting - Carbon Trade and Carbon Market - Climate Change Mitigation Efforts in India	

**PART 9:
EVENTS AND ORGANIZATIONS**

Chapter 40	International Conferences, Meetings and Conventions – <i>M. Senthil Kumar</i>	741-763
Chapter 41	International and National Forest Organizations – <i>Antony Joseph Raj</i>	764-786
	Intergovernmental Organizations - Non-Governmental Organizations - International Research Institutes - Regional Institutes - Indian Forestry Research & Education Organizations	
	Bibliography	787-805

LIST OF TABLES

Table 1.1	Three Types of Weathering	16
Table 1.2	C:N Ratio of Organic Matter and Soils	23
Table 1.3	Composition of Humus	25
Table 2.1	Basin-wise Average Flow and Utilizable Water (in km ³ /year)	27
Table 2.2	Groundwater Resources of India (in km ³ /year)	28
Table 2.3	State-wise Dynamic Fresh Groundwater Resource of India (in km ³ /year)	29
Table 2.4	Groundwater Potential in River Basins of India (pro-rata basis) (in km ³ /year)	30
Table 2.5	Per-capita per year Availability and Utilizable Surface Water in India (in m ³)	31
Table 2.6	Annual Water Requirement for Different Uses (in km ³)	33
Table 3.1	Global Forest Cover by Region	42
Table 3.2	Forest and Tree Cover of India	44
Table 3.3	Forest Cover in Different Forest Type Groups	46
Table 4.1	Zoogeographic Divisions of World	56
Table 4.2	Zoogeographic Regions of World	56
Table 4.3	State-wise Details of the Protected Area Network of India	68
Table 4.4	National Parks and Wildlife Sanctuaries in India	69
Table 4.5	List of some important Wildlife Sanctuaries and National Parks in India	70
Table 5.1	Vegetation Types of India	79
Table 5.2	Trees Removed during different intensities of Low Thinning	91
Table 6.1	Life-Form Classes	103
Table 7.1	Group-wise Record of Species	108
Table 7.2	Number of Global Species under Threat	113
Table 7.3	The Hotspots of the World	116
Table 7.4	List of Biosphere Reserves of India	122
Table 7.5	List of Prioritized Medicinal Plants in India	127
Table 9.1	History of Plantation Forests in the World	153
Table 9.2	Status of Global Planted Forest Development	154

Table 10.1	Features of the ITTO Guidelines Concerning Sustainable Forest Management at National and Forest Levels	171
Table 11.1	Structure of Organization at Central Level	176
Table 11.2	Structure of Organization at State Level	177
Table 11.3	Index Used for the Purpose of Stock Mapping in Sal Forests	182
Table 11.4	Method of Recording inside Regeneration Plot	186
Table 11.5	Grading of Regeneration	186
Table 11.6	Yield Regulation for Three Silvicultural Systems	187
Table 11.7	Working Plan Vs Management Plan	187
Table 12.1	Spiegel Relaskop Bands and BAFs	208
Table 12.2	Sample Plots Size for Different Stocking Rates that will include about 20 trees	209
Table 13.1	Predators of Insect Pests	223
Table 13.2	Parasitoids of Insect Pests	224
Table 14.1	Diseases along with Causal Pathogens occurring in Important Tree Species	236
Table 16.1	Characteristics of Salt Affected Soils	270
Table 16.2	Properties of Saline and Sodic Soils	272
Table 16.3	Liming Materials	276
Table 16.4	Tree Species Suitable for various Problematic Soils	279
Table 17.1	Practical Maturity Indices for Forest Tree Fruits	286
Table 17.2	Criteria for Judging the Maturation of different Tropical Forest Species	287
Table 17.3	Seed Collection Months of <i>Dalbergia sissoo</i> in different States	288
Table 17.4	List of Major Insect Pests and Damage to Fruits/Cones /Seeds on Standing Trees	290
Table 17.5	Summary of Extraction Methods for various Fruit Types	291
Table 17.6	Seed Extraction Methods of Fleshy Fruits	293
Table 18.1	Phases of Species Trial	312
Table 18.2	Phases of Provenance Trial	313
Table 18.3	Plus Tree Record Form	317
Table 18.4	Comparison between Seedling Seed Orchard and Clonal Seed Orchard	319
Table 18.5	Comparison of Advantages and Disadvantages of Different Methods of Progeny Testing	324
Table 21.1	Number of Documented Species in World and India	361
Table 21.2	Growth of Protected Areas in India	362
Table 21.3	Protected Area Details in various Biogeographic Zones	364
Table 21.4	List of Ramsar Sites in India	365
Table 21.5	List of Natural World Heritage Sites in India	366
Table 21.6	List of Tiger Reserves in India	368
Table 23.1	Methods for Valuing Forests	414

Table 25.1	Major Tree Borne Oil Seeds	439
Table 25.2	Projected Demand of RWE for Sawn Wood Based Industries (million m ³)	440
Table 25.3	Projected Demand of RWE for Pulpwood Based Industries (million m ³)	440
Table 25.4	Projected Demand of RWE for Sleeper, Round Wood and Mine-Prop etc. (million m ³)	441
Table 28.1	Comparison of Energy Species with Possible Potential	486
Table 28.2	Botanical Names, Percentage of Oil/ Fat, Uses and Potential States of some of the TBOs as source of Bio-diesel Production in India	488
Table 29.1	Per Capita Urban Green Space or Urban Forests in Important Cities	506
Table 29.2	Important Urban Trees with Colourful Flowers	514
Table 29.3	Urban Trees with Colourful Fruits or Seeds	514
Table 30.1	Classification of Agroforestry Systems and Practices	526
Table 30.2	Multipurpose Tree Species suitable for Agroforestry in India	530
Table 30.3	List of Soil Improvement Tree Species for Agroforestry	531
Table 30.4	Promising Agroforestry Models for Agro-Climatic Zones of India	534
Table 30.5	Agroforestry Practices in Different Agro-Ecological Regions of India	536
Table 30.6	Analysis of Interactions between Two Populations of Species A and B	537
Table 31.1	Social Forestry Programmes Implemented in Gujarat	551
Table 31.2	Cumulative Achievement of Social Forestry Works (1969-70 to 2003-04) in Gujarat	551
Table 31.3	List of Completed Social Forestry Projects	558
Table 32.1	State Trading Regulations Promulgated by State Governments	570
Table 32.2	JFM as Percentage of Forest Cover in different States of India	571
Table 32.3	Participants involved in JFM in different States of India	572
Table 32.4	Financial Assistance Received from External Donor Agencies for JFM	573
Table 33.1	Classification of Land based on Aridity Index	580
Table 33.2	Wasteland Classes in India 1986-2000	588
Table 33.3	Land Degradation Assessment by Different Organizations	590
Table 33.4	Types of Land Degradation and Improvement	596
Table 34.1	Production Level of Top Ten Paper Producing Countries in 2010	615
Table 34.2	The world's Top 20 Paper and Paperboard Company Groups in 2010	616
Table 36.1	Major Primitive Forest Tribes of India	654
Table 36.2	State-Wise Demographic Status of Forest Tribes in India	655
Table 36.3	Trends in Growth and Proportion of Forest Tribes in India	657
Table 37.1	Classification of Gullies based on the Size	675
Table 37.2	Classification of Gullies based on the Shape	675
Table 37.3	Classification of Gullies based on the State	675

Table 38.1	Tropospheric Concentration, GWP, Lifetime, Increased Radiative Forcing of Greenhouse Gases	697
Table 38.2	Total Increase and Annual Rate of Increase in CO ₂ during different Decades	697
Table 38.3	Summary of Published Change in Forest Productivity under recent Climate Change	702
Table 39.1	CO ₂ Emissions from Fossil Fuel Combustion in 2009 of Top Ten Countries and World	716
Table 39.2	Total Carbon Emissions of Top Ten Countries and World	716
Table 39.3	Trends in Total Carbon Stocks in World's Forests, 1990-2010	721
Table 39.4	Carbon Stock in Indian Forests	721
Table 39.5	Carbon Sequestration Practices	722
Table 39.6	Carbon Market Evolution Values in \$ Billion	734

LIST OF FIGURES

Fig. 1.1	Overview of Forest Nutrient Cycling	13
Fig. 3.1	Forest Cover Map of India	45
Fig. 5.1	Thematic Diagram of Tree	78
Fig. 6.1	Energy Flow in an Ecosystem	96
Fig. 6.2	Succession in Forest Ecosystem	97
Fig. 6.3	Vertical Structure in Forest Ecosystem	99
Fig. 8.1	Scheme of Classification under Bentham and Hooker's System	131
Fig. 8.2	Outline of Bentham and Hooker's Natural Classification	132
Fig. 8.3	Bentham and Hooker's Classification of Sub Class Polypetalae	133
Fig. 8.4	Bentham and Hooker's Classification of Sub Class Gamopetalae	133
Fig. 8.5	Bentham and Hooker's Classification of Sub Class Apetalae	134
Fig. 8.6	Bentham and Hooker's Classification of Class Monocots	134
Fig. 11.1	Layout of Sample Plot (0.1 ha) for Enumeration, Regeneration Survey and Biodiversity Survey	185
Fig. 12.1	Under Bark and Over Bark DBH Measurements	191
Fig. 12.2	Diameter Calliper	192
Fig. 12.3	Wheeler's Pentaprism Caliper	194
Fig. 12.4	Height Measurement using Christen Hypsometer	198
Fig. 12.5	Height Measuring Instruments	200
Fig. 12.6	Geometric Shape of Tree Stems/Logs	202
Fig. 12.7	Wedge Prism Usage	208
Fig. 17.1	Types of Materials Removed from Harvested Produce during Processing	295
Fig. 18.1	Sequence of Stages in Tree Improvement	310
Fig. 18.2	Regression Line for Plus Tree Selection	318
Fig. 18.3	Establishment of Seedling Seed Orchard	322
Fig. 18.4	Establishment of Clonal Seed Orchard	323
Fig. 19.1	Vascular Bundles and Vascular Cambium	334

Fig. 19.2	Meristems and Vascular Cambium Growth	335
Fig. 19.3	Cross-section of Tree Stem	337
Fig. 19.4	Three Methods of Sawing	338
Fig. 19.5	Warping Defects	348
Fig. 23.1	Division of Total Economic Value	403
Fig. 24.1	Components of Remote Sensing	422
Fig. 24.2	Components of GIS	428
Fig. 25.1	Categorization of the Paper Mills Based on Cellulosic Raw Materials	435
Fig. 25.2	Value Addition of Plantation Residues through Briquetting	440
Fig. 25.3	A Value Chain Model for Industrial Forestry	441
Fig. 25.4	Status of Industrial Wood Supply Chain	443
Fig. 25.5	Tri-partite Model contract tree farming	444
Fig. 25.6	Quad-Partite Model Contract Tree Farming	445
Fig. 25.7	Industrial Forestry Trees	447
Fig. 25.8	Industrial Forestry	448
Fig. 26.1	Types of Feller Buncher	459
Fig. 26.2	Types of Yarder	462
Fig. 26.3	Types of Delimber	463
Fig. 26.4	Types of Loader	465
Fig. 28.1	Bio-diesel Production Reaction	499
Fig. 28.2	Flow Diagram for Production of Bio-diesel	499
Fig. 30.1	Benefits of MPTs - '6Fs'	529
Fig. 30.2	Comparison of Pattern of Nutrient Cycling in Forest, Agriculture and Agroforestry	532
Fig. 30.3	Pattern of Nutrient Cycling under Agroforestry	533
Fig. 34.1	Composite Woods	609
Fig. 37.1	Soil Erosion Agents	673
Fig. 37.2	Water Erosion Control Measures	680
Fig. 38.1	Costs of Climate Change as percentage of GDP	695
Fig. 38.2	The Greenhouse Effect	698
Fig. 39.1	Global Carbon Cycle – Units in Gigaton Carbon	712
Fig. 39.2	Trend in Global Carbon and CO ₂ Emissions from Fossil Fuel Combustion	717
Fig. 39.3	Flow Diagram for Estimation of Carbon Sequestration in Forest Ecosystem	725

ABBREVIATIONS AND ACRONYMS

AAUs	: Assigned Amount Units
ABA	: Abscisic Acid
ACF	: Assistant Conservator of Forests
AI	: Aridity Index
AOSA	: Association of Official Seed Analysts
APCCF	: Additional Principal Chief Conservator of Forests
APFC	: Asia-Pacific Forestry Commission
ASEAN	: Association of South East Asian Nations
ATO	: African Timber Organization
AYUSH	: Department of Ayurveda, Yoga & Naturopathy, Unani, Siddha & Homeopathy
BAF	: Basal Area Factor
BC	: Buffering Capacity
BDA	: Biological Diversity Act
B-I Process	: Bhopal-India Process
BMC	: Biodiversity Management Committees
BR	: Biosphere Reserve
BSI	: Botanical Survey of India
C&I	: Criteria and Indicators
C:N Ratio	: Carbon Nitrogen Ratio
CAI	: Current Annual Increment
CAZRI	: Central Arid Zone Research Institute
CBD	: Convention on Biological Diversity
CBF	: Central Board of Forestry
CBP	: Conservation Breeding Programme
CBT	: Conservation Bench Terraces
CCF	: Chief Conservator of Forests
CCS	: Carbon Capture and Sequestration

CDM	: Clean Development Mechanism
CEC	: Cation Exchange Capacity
CERs	: Certified Emission Reductions
CF	: Conservator of Forests
CGIAR	: Consultative Group on International Agricultural Research
CIFOR	: Centre for International Forestry Research
CITES	: Convention on International Trade in Endangered Species of Wild Fauna and Flora
CMS	: Convention on the Conservation of Migratory Species of Wild Animals
COC	: Chain of Custody
COFO	: Committee on Forestry
COP	: Conference of the Parties
CPF	: Collaborative Partnership on Forests
CR	: Contingent Ranking
CSD	: United Nations Commission on Sustainable Development
CSIRO	: Commonwealth Scientific and Industrial Research Organization
CSO	: Clonal Seed Orchard
CVM	: Contingent Valuation Method
CWLW	: Chief Wild Life Warden
CZA	: Central Zoo Authority
DANIDA	: Danish International Developmental Agency
dbh	: diameter at breast height
DBHOB	: Diameter at Breast Height Over Bark
DCF	: Deputy Conservator of Forests
DF	: Diesel Fuel
DFO	: Divisional Forest Officer
DoLR	: Department of Land Resources
ECOSOC	: United Nations Economic and Social Council
EIA	: Environmental Impact Assessment
EMC	: Equilibrium Moisture Content
ENSO	: El Nino - Southern Oscillation
ERUs	: Emission Reduction Units
ESP	: Exchangeable Sodium Percent
FAO	: Food and Agricultural Organization of the United Nations
FDA	: Forest Development Agency
FFA	: Free Fatty Acids
FMU	: Forest Management Unit
FORWORKNET	: Forestry Workforce Network

FPC	: Forest Protection Committee
FRA	: Global Forest Resources Assessment
FRI	: Forest Research Institute
FRM	: Forest Reproductive Material
FSC	: Forest Stewardship Council
FSI	: Forest Survey of India
FSO	: Forest Settlement Officer
FSP	: Fibre Saturation Point
FYM	: Farm Yard Manure
FYP	: Five Year Plan
GA	: Gibberellic Acid
GA	: Genetic Advance
GATT	: General Agreement on Tariffs and Trade
GCA	: General Combining Ability
GEF	: Global Environment Facility
GFMC	: Global Fire Monitoring Center
GHGs	: Green House Gases
GIM	: Green India Mission
GIS	: Geographic Information System
GLASOD	: Global Assessment of Soil Degradation
GM	: Genetically Modified
GPS	: Global Positioning System
GtC	: Gigatons of Carbon
GWP	: Global Warming Potential
HYV	: High Yielding Variety
IAA	: Indole Acetic Acid
IBA	: Indole Butyric Acid
IBWL	: Indian Board for Wildlife
ICAR	: Indian Council of Agricultural Research
ICBN	: International Code of Botanical Nomenclature
ICFRE	: Indian Council of Forestry Research and Education
ICIMOD	: International Centre for Integrated Mountain Development
ICRAF	: World Agroforestry Centre
IFAD	: International Fund for Agricultural Development
IFF	: Intergovernmental Forum on Forests
IIFM	: Indian Institute of Forest Management
IIRS	: Indian Institute of Remote Sensing

IPCC	: Intergovernmental Panel on Climate Change
IPF	: Intergovernmental Panel on Forests
IPIRTI	: Indian Plywood Industries Research and Training Institute
IPM	: Integrated Pest Management
ISRO	: Indian Space Research Organisation
ISTA	: International Seed Testing Association
ITTA	: International Tropical Timber Agreement
ITTO	: International Tropical Timber Organization
IUCN	: International Union for Conservation of Nature
IUDZG	: International Union of Directors of Zoological Gardens
IUFRO	: International Union of Forest Research Organizations
IVI	: Importance Value Index
IWRM	: Integrated Water Resources Management
JFM	: Joint Forest Management
JFMC	: Joint Forest Management Committees
JI	: Joint Implementation
KFRI	: Kerala Forest Research Institute
LaCONES	: Laboratory for Conservation of Endangered Species
LADA	: Land Degradation Assessment in Drylands
LULUCF	: Land Use, Land Use Change and Forestry
M ha	: Million Hectare
MA	: Millennium Ecosystem Assessment
MAB	: The Man and the Biosphere Programme
MAI	: Mean Annual Increment
MAP	: Medicinal and Aromatic Plants
MC	: Moisture Content
MDGs	: Millennium Development Goals
MOA	: Ministry of Agriculture
MoEF	: Ministry of Environment and Forests
MOP	: Meetings of Parties of the Kyoto Protocol
MoRD	: Ministry of Rural Development
MPT	: Multipurpose Tree
MUSLE	: Modified Universal Soil Loss Equation
MW	: Megawatt
MXD	: Maximum Latewood Density
NAEB	: National Afforestation and Eco-Development Board
NAPCD	: National Action Programme to Combat Desertification

NBA	: National Biodiversity Authority
NBSS&LUP	: National Bureau of Soil Survey and Land Use Planning
NCA	: National Commission on Agriculture
NCDMA	: National CDM Authority
NFAP	: National Forestry Action Programme
NFT	: Nitrogen Fixing Tree
NLBI	: Non-Legally Binding Instrument on All Types of Forests
NMPB	: National Medicinal Plants Board
NPV	: Nuclear Polyhedrosis Virus/ Net Present Value
NRCAF	: National Research Centre for Agroforestry
NRSA	: National Remote Sensing Agency
NRSC	: National Remote Sensing Center
NTFP	: Non-Timber Forest Products
NWDB	: National Wasteland Development Board
NWFP	: Non-Wood Forest Products
OECD	: Organisation for Economic Co-operation and Development
OM	: Organic Matter
PA	: Protected Area
PCCF	: Principal Chief Conservator of Forests
PCR	: Polymerase Chain Reaction
PIP	: Pugmark Impression Pads
POPs	: Convention on Persistent Organic Pollutants
PRA	: Participatory Rural Appraisal
PROFOR	: Programme on Forests
PTGs	: Primitive Tribal Groups
PVTGs	: Particularly Vulnerable Tribal Groups
PWPR	: Preliminary Working Plan Report
RAPD	: Random Amplified Polymorphic DNA
REDD	: Reducing Emissions from Deforestation and forest Degradation
RFLP	: Restriction Fragment Length Polymorphism
RFO	: Range Forest Officer
RIL	: Reduced Impact Logging
RMUs	: Removal Units
RSG	: Re-introduction Specialist Group
RUPFOR	: Resource Unit for Participatory Forestry
RWE	: Round Wood Equivalent
SBA	: Stand Basal Area

SBB	: State Biodiversity Boards
SCA	: Specific Combining Ability
SFM	: Sustainable Forest Management/ Soil Fertility Management
SIA	: Social Impact Assessment
SLEM	: Sustainable Land and Ecosystem Management
SMPB	: State Medicinal Plants Board
SOC	: Soil Organic Carbon
SOFO	: State of the World's Forests
SOM	: Soil Organic Matter
SPA	: Seed Production Area
SSO	: Seedling Seed Orchard
SSR	: Simple Sequence Repeat
TBA	: Tree Basal Area
TBOs	: Tree Borne Oilseeds
TEV	: Total Economic Value
TIES	: The International Ecotourism Society
TOF	: Trees Outside Forests
UNCCD	: United Nations Convention to Combat Desertification
UNCED	: United Nations Conference on Environment and Development
UNCHE	: United Nations Conference on the Human Environment
UNCOD	: United Nations Conference on Desertification
UNCTAD	: United Nations Conference on Trade and Development
UNDESA	: United Nations Department of Economic and Social Affairs
UNDP	: United Nations Development Programme
UNEP	: United Nations Environment Programme
UNESCO	: United Nations Educational, Scientific and Cultural Organization
UNFCCC	: United Nations Framework Convention on Climate Change
UNFF	: United Nations Forum on Forests
UNISDR	: United Nations International Strategy for Disaster Reduction
UNPFII	: United Nations Permanent Forum on Indigenous Issues
UNWTO	: United Nations World Tourism Organization
USEPA	: United States Environmental Protection Agency
USLE	: Universal Soil Loss Equation
VA	: Village Associations
VERs	: Verified Emission Reductions
VFC	: Village Forest Committee
WAZA	: World Association of Zoos and Aquariums

WBG	: World Bank Group
WCFSO	: World Commission on Forests and Sustainable Development
WF	: Weightage Factor
WHC	: World Heritage Convention
WII	: Wildlife Institute of India
WMO	: World Meteorological Organization
WPO	: Working Plan Officer
WSSD	: World Summit on Sustainable Development
WTA	: Willingness To Accept
WTO	: World Trade Organization
WTP	: Willingness To Pay
WWF	: World Wide Fund for Nature

PART 1:

NATURAL RESOURCES

