

# Agroforestry for Climate Resilience and Rural Livelihood



Inder Dev    Asha Ram    Naresh Kumar    Ramesh Singh  
Dhiraj Kumar    A.R. Uthappa    A.K. Handa    O.P. Chaturvedi

 SCIENTIFIC  
PUBLISHERS



# **Agroforestry for Climate Resilience and Rural Livelihood**

## OTHER RELATED BOOKS

Title	Author	ISBN
• A Manual for Dryland Afforestation and Management	<i>G. Singh</i>	9788172339784
• A Text Book of Environmental Science	<i>Vidya Thakur</i>	9788172337568
• Agroforestry: Theory and Practices	<i>A.J. Raj</i>	9788172338664
• Applied Microbiology (Agriculture, Environmental, Food and Industrial Microbiology)	<i>S.M. Reddy</i>	9789386237903
• Biodiversity Conservation	<i>M.S.B. Kumar</i>	9788172334893
• Biodiversity, Traditional Knowledge and Intellectual Property Rights	<i>S.R. Reddy</i>	9788172339692
• Forest Fires and their Control	<i>E.S. Artsybashev</i>	9789383692590
• Forest Mensuration: A Handbook for Practitioners	<i>G.J. Hamilton</i>	9789388399012
• Forest Nursery: How to Raise and Manage	<i>S.S. Sagwal</i>	9789388043991
• Forest Tree Seeds: Handbook	<i>S.S. Sagwal</i>	9789388043663
• Forest Tribology and Anthropology	<i>V.M. Mhaiske</i>	9788172339661
• Forestry Extension Making it Work	<i>Wazeka</i>	9789388399128
• Forestry Extension Methods	<i>D. Sim</i>	9789388399029
• Forestry: Principles and Applications	<i>A.J. Raj</i>	9788172338107
• Forestry Research Extension: Challenges & Strategies	<i>C.S. Dange</i>	9788172335960
• Forestry Technologies: A Complete Value Chain Approach	<i>K.T. Parthiban</i>	9789386102607
• Industrial Agroforestry: Perspectives and Prospectives	<i>K.T. Parthiban</i>	9788172339050
• Introduction to Forestry & Agroforestry	<i>K.T. Parthiban</i>	9789388172677
• Nursery and Plantation Practices in Forestry	<i>Vinod Kumar</i>	9788172337155
• Plantation and Agroforestry Pulpwood Value Chain Approach	<i>K.T. Parthiban</i>	9789386347985
• Sacred Groves of Rajasthan	<i>G. Singh</i>	9789386102881
• Shushk Kshetra Varnikaran Evam Van Prabandhan: Takniki Evam Kaaryavidhiya	<i>G. Singh</i>	9789386237941
• Silvipasture in India: Present Perspectives and Challenges Ahead	<i>D.R. Palsaniya</i>	9788172336868
• Training Manual for Applied Agroforestry Practices	<i>Michael Gold</i>	9789388399104
• Tree Mortality Assesment and Mitigation	<i>J.D.S. Negi</i>	9788172339876
• Tropical Forest Ecosystems Structure and Function	<i>V.P. Singh</i>	9788172333706
• Vegetational Wealth of Aravalli Ranges	<i>A.M. Otaghvari</i>	9788172339265
• Wildlife Ecology and Conservation	<i>M. Balakrishnan</i>	9788172339746
• Wood Handbook: Wood as an Engineering Material	<i>Usda</i>	9789388399111

For complete details visit [www.scientificpub.com](http://www.scientificpub.com)

# **Agroforestry for Climate Resilience and Rural Livelihood**

**EDITORS**

**Inder Dev  
Ramesh Singh  
A.K. Handa**

**Asha Ram  
Dhiraj Kumar  
O.P. Chaturvedi**

**Naresh Kumar  
A.R. Uthappa**



Published by

SCIENTIFIC PUBLISHERS (INDIA)

5 A, New Pali Road, P.O. Box 91

Jodhpur 342 001 (INDIA)

E-mail: [info@scientificpub.com](mailto:info@scientificpub.com)

Website: <http://www.scientificpub.com>

© 2019 Authors

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 publisher.

Disclaimer: Whereas every effort has been made to avoid errors and omissions, this publication is being sold on the understanding that neither the editors (or authors) 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 publisher, for rectifying it in future editions, if published.

This book contains information obtained from authentic and highly regarded sources. Reasonable efforts have been made to publish reliable data and information, but the editors and publisher cannot assume responsibility for the validity of all materials or the consequences of their use. The editors and publisher have attempted to trace and acknowledge the copyright holders of all material reproduced in this publication and apologize to copyright holders if permission and acknowledgment to publish in this form have not been obtained. If any copyright material has not been acknowledged please write and let us know so that we may rectify it.

Trademark Notice: Product or corporate names may be trademarks or registered trademarks, and are used only for identification and explanation without intent to infringe.

ISBN: 978-93-87309-06-3 (Hardbound)

ISBN: 978-93-87991-92-7 (Ebook)

Printed in India



त्रिलोचन महापात्र, पीएच.डी.

एफ एन ए, एफ एन ए एस सी, एफ एन ए ए एस  
सचिव एवं महानिदेशक

**TRILOCHAN MOHAPATRA, Ph.D.**

FNA, FNAsc, FNAAS

SECRETARY & DIRECTOR GENERAL

भारत सरकार

कृषि अनुसंधान और शिक्षा विभाग एवं

भारतीय कृषि अनुसंधान परिषद

कृषि एवं किसान कल्याण मंत्रालय, कृषि भवन, नई दिल्ली 110 001

GOVERNMENT OF INDIA

DEPARTMENT OF AGRICULTURAL RESEARCH & EDUCATION  
AND

INDIAN COUNCIL OF AGRICULTURAL RESEARCH

MINISTRY OF AGRICULTURE AND FARMERS WELFARE

KRISHI BHAVAN, NEW DELHI 110 001

Tel.: 23382629; 23386711 Fax: 91-11-23384773

E-mail: dg.icar@nic.in

## FOREWORD

Agroforestry is a traditional land use system that balances productivity *vis-à-vis* ecological services, thus discussed globally for its relevance in mitigation of climate change impacts. Agroforestry meets almost half of the demand of fuelwood, two-thirds of small timber, 70–80% wood of plywood, 60% raw material for paper pulp and 9–11% of the green fodder requirements, in addition to various environmental benefits. Adoption of agroforestry on large scale thus offers a great potential and appears to be the most desirable strategy for maintaining social, economic and ecological sustainability in the country. At present, 25.32 million ha is under agroforestry, which is about 8.32% of total geographic area of the country. The Task Force on Greening India (Planning Commission, 2001) had further recommended an additional 28 million ha area to be brought under plantation through agroforestry to achieve one-third of the total geographical area of the country under forest cover. To this effect, India is the only South Asian country to have enacted 'National Agroforestry Policy' in the year 2014.

I am sure that this book “**Agroforestry for Climate Resilience and Rural Livelihood**” is an excellent reference for those seeking knowledge on importance of agroforestry providing livelihood and ecosystem services enabling climate resilience. This volume covering novel information on agroforestry will be of immense use to policy makers, planners, scientists, academicians, and students working in the field of agroforestry.

( T. MOHAPATRA )

**Dated the 8<sup>th</sup> January, 2018**  
**New Delhi**



# Preface

Developing countries mostly rely on agriculture for rural livelihood and food security. Nevertheless, these countries have maximum vulnerability for agricultural production system due to high dependency on rainfall and climate change. On the other hand, land degradation exacerbates the productivity decline. In present scenario, the goal of sustainable development could only be achieved through diversification of existing cropping systems by promoting the integration of trees in different land use systems. Infact, agroforestry is one of the prime options for attaining the target of 33% of forest cover. Apart from nutritional security, agroforestry also provide other benefits like climate change mitigation and adaptation, land tenure security, increased farm income, restoration and maintenance of above and below ground carbon storage capacity, restoration and maintenance of biodiversity, watershed hydrology and soil conservation. Majority of farmers in our country belong to marginal and small category, who struggle every day to meet out their livelihood and to perform the farming practices under the threat of aberrant weather conditions. Thus, it is high time for them to adopt the agroforestry practices to meet out their livelihood requirements and also to sustain productivity with economic security and minimum environmental degradation. This compiled book entitled “Agroforestry for Climate Resilience and Rural Livelihood” would definitely be helpful for policy makers, planners, academicians, students and scientists to suggest the technologies and strategies to the farmers for enhancing their productivity, economic stability, meeting nutritional security under the changing climatic scenario. The voluminous compilation will act as a boost for farmers to adopt agroforestry system in their pursuit for better environmental management and resilience against the climate change. We have segregated the contents of our book under two theme areas, climate resilience and rural livelihood.

We are very thankful to the authors for their contributions in the form of chapters dealing with different aspects of agroforestry, climate change and nutritional security. We are really very pleased to bring this publication by compiling the information received through various experts working in the field of agroforestry and brought number of case studies from different quarters of the country and the issues related to present scenario. The views of the readers on this edition will be highly appreciated for improvement and guidance in future editions.

**Editors:**

*Inder Dev, Asha Ram, Naresh Kumar, Ramesh Singh  
Dhiraj Kumar, AR Uthappa , AK Handa, OP Chaturvedi*

### **BRIEF BIODATA OF DR. INDER DEV**



Dr. Inder Dev was born on 20th November, 1968 at village Tharass in Kullu district of Himachal Pradesh. He has devoted about 21 years of his career in research, extension and management in silvipastoral management, grassland management of temperate, alpine and cold desert region of the Himalaya; watershed management and agroforestry in semi-arid CSK Himachal Pradesh Krishi Vishwavidyalaya, Palampur, Himachal Pradesh and Ph. D (Agronomy) from IARI, New Delhi. He also obtained an International Diploma in Professional Capacity Building Programme in Agricultural Research for Development from International Centre for Development research publications in refereed journals.

Agroforestry Research Institute, Jhansi, Uttar Pradesh, India, with a major focus on Agroforestry based conservation agriculture and watershed management.

### **BRIEF BIODATA OF DR ASHA RAM**



district of Rajasthan. He has a PhD in Agronomy with emphasis on soil productivity of wasteland through silvipasture management with soil and moisture conservation practices, Agroforestry based Integrated farming system, tree-crop interactions study in agroforestry systems and agroforestry based

scientist (Agronomy) at the Indian Council of Agricultural Research (ICAR) - Central Agroforestry Research Institute (CAFRI), Jhansi, Uttar Pradesh, India.

### **BRIEF BIODATA OF DR. NARESH KUMAR**



Pradesh. He did his B.Sc. (Forestry), M.Sc. (Forestry) and Ph. D. (Agroforestry) from Dr. Y.S. Parmar University of Horticulture and Forestry, Solan, Himachal Pradesh. He has been engaged in teaching and research for more than 12 years and

College of Horticulture and Forestry, Central Agricultural University, Pasighat,

- Central Agroforestry Research Institute (CAFRI), Jhansi, Uttar Pradesh, India. He is associated with different research projects focusing on short rotation tree species, improvement of wastelands through silvipastoral system, agroforestry based farming system, conservation agriculture etc.

### **BRIEF BIODATA OF DR. RAMESH SINGH**



Dr. Ramesh Singh was born on 1st July, 1970 at village Ori in Mirzapur district of watershed management and hydrology of agroforestry systems. He did his B. Tech

publications and conducted national and international trainings on NRM. He has

At present, Dr. Ramesh Singh is working as PS (SWC Engg.) at ICAR-Central Agroforestry Research Institute, Jhansi with a major focus on management of natural resources through agroforestry led watershed interventions.

#### BRIEF BIODATA OF DR. DHIRAJ KUMAR



Dr. Dhiraj Kumar was born on 19th March, 1987 at Hazaribagh district of Jharkhand. He did his B.Sc. Agriculture (Hons.) from UBKV, Pundibari, Cooch Behar (West Bengal) and M.Sc. as well as Ph.D. in Soil Science and Agricultural Chemistry from Indian Agricultural Research Institute (IARI), New Delhi. He has already contributed nine research papers, six book chapters, three technical bulletins, research reports and popular articles published in journals of repute. His major area of interest is soil carbon and nitrogen dynamics studies. Presently, he is involved in studies on tree-crop interaction, soil biological parameters under conservation agriculture based agroforestry system, soil quality assessment in agroforestry based watershed interventions etc. At present Dr. Dhiraj Kumar is working as Scientist (Soil Science) at ICAR-Central Agroforestry Research Institute, Jhansi, Uttar Pradesh, India, with a major focus on fine roots and litter dynamics studies under agroforestry system.

#### BRIEF BIODATA OF UTHAPPA A R



Uthappa A R was born on 20 May 1987 at village Ponnampet in Kodagu district of Karnataka. He did his B.Sc. Forestry from UAS, Bangalore, Karnataka and M.Sc. (Agriculture) in Agroforestry from GBPUAT, Pantnagar, Uttarakhand. He has published more than 20 research papers, popular articles and book chapters in different refereed journals and books. He has also authored two books. At present he is working as a Scientist (Agroforestry) at ICAR-Central Agroforestry Research Institute, Jhansi, Uttar Pradesh, India, with a major focus on Tree Improvement of fodder trees and Agroforestry based conservation agriculture.

#### BRIEF BIODATA OF DR. A.K. HANDA



Dr. A.K. Handa was born on 21.08.1967. Dr A K Handa is B.Sc., M.Sc. and Ph.D. in Forestry from Dr Y S Parmar University of Horticulture and Forestry, Solan, Himachal Pradesh. He has an experience of more than 23 years of research and development in the field of Agroforestry / Forestry. He has been Principal Investigator of different research projects including externally funded projects. He has more than 80 research and technical publications to his name published in International and National journals. He was been awarded with Dr K G Tejwani Award for Agroforestry 2013. He is currently working as Principal Scientist (Agroforestry) at ICAR- Central Agroforestry Research Institute, Jhansi, Uttar Pradesh, India.

#### CURRICULUM VITAE OF DR. O.P. Chaturvedi



Dr. O.P. Chaturvedi was born on 1st January, 1956 at Barwan, Uttar Pradesh. He did his Ph.D. from Kumaun University, Nainital. He has an experience of more than 36 years of research and teaching in the field of Agroforestry / Forestry. He is specialized in Forestry; agroforestry; agrisilvicultural systems; agrihorticultural systems; silvipastoral systems; quality plant production; growth and production modeling of trees; wasteland reclamation and development; watershed management and development on ecosystem basis. He was been awarded with number of prestigious awards such as Forestry Teacher Award U.K. 1988, Overseas Technical Trainers Award U.K., 1989, K G Tejwani Award for Agroforestry 2008 and NAAS Fellow Award 2008. Dr. O.P. Chaturvedi was Ex. Director of ICAR- Central Agroforestry Research Institute, Jhansi, Uttar Pradesh, India.



# List of Contributors

A Balasubramanian	Forest College and Research Institute, Mettupalayam, Coimbatore, TamilNadu, India
A Pattanayak	ICAR- Vivekananda Parvatiya Krishi Anusandhan Sansthan, Almora, India
Anand Kumar Singh	ICAR-Central Agroforestry Research Institute, Jhansi, India
A. G. Yewale	Uttarakhand University of Horticulture and Forestry, Tehri Garhwal, Uttarakhand, India
A.R. Uthappa	ICAR-Central Agroforestry Research Institute, Jhansi, India
Abhishek M Tripathi	Global Change Research Institute AS CR, Brno, Czech Republic
AK Handa	ICAR-Central Agroforestry Research Institute, Jhansi, India
AK Singh Parihar	N.D. University of Agriculture & Technology, Kumarganj, Faizabad
Anil Kumar	Navsari Agricultural University, Navsari, Gujarat, India
Anil Kumar	ICAR-Central Agroforestry Research Institute, Jhansi, India
Ankur Jha	Krishi Vigyan Kendra, Auraiya, Uttar Pradesh, India
AR Manju hashini	Forest College and Research Institute, Mettupalayam, Coimbatore, TamilNadu, India
Asha Ram	ICAR-Central Agroforestry Research Institute, Jhansi, India
Ashish Yadav	ICAR-National Organic Farming Research Institute, Sikkim, India
Atul Shrivastava	Jawaharlal Nehru Krishi Vishwa Vidyalaya, Jabalpur, Madhya Pradesh, India
B Palanikumar	Tamil Nadu Agricultural University, Tamil Nadu, India
Babli Joshi	SCVB Govt. Collee, Palampjur (H.P), India.
Badre Alam	ICAR-Central Agroforestry Research Institute, Jhansi, India
BH Kittur	University of Agricultural Sciences, Dharwad, India
Bimlendra Kumari	CCS Haryana Agricultural University, Hisar, India
BM Kumar	Nalanda University, Rajgir, District Nalanda, Bihar, India
BM Pandey	ICAR- Vivekananda Parvatiya Krishi Anusandhan Sansthan, Almora, India
BP Mishra	College of Horticulture and Forestry, CAU Pasighat, Arunachal Pradesh, India
BS Kasana	Rajmata Vijayaraje Scindia Krishi Vishwa Vidyalaya, Gwalior, India
C Cinthia fernandaz	Tamil Nadu Agricultural University, Tamil Nadu, India

C Valli	Tamil Nadu Veterinary and Animal Sciences University,
C.Bandeswaran	Tamil Nadu Veterinary and Animal Sciences University,
CB Pandey	ICAR-Central Arid Zone Research Institute, Jodhpur, India
Chaman Lal	Dr. Y. S. Parmar UHF, Nauni, Himachal Pradesh, India
CP Rahangdale	Jawaharlal Nehru Krishi Vishwa Vidyalaya, Jabalpur, Madhya Pradesh, India
D.R. Palsaniya	
D.S.Chauhan	
DB Patel	
Dhiraj Kumar	ICAR-Central Agroforestry Research Institute, Jhansi, India
Dinesh Kumar	Institute of Agricultural Sciences, Banaras Hindu University, Varanasi, India
DSN Raju	
	Dr. Y.S. Parmar University of Horticulture and Forestry, Nauni, Solan, India
H Suvera	
H. Mehta	ICAR-Indian Institute of Soil and Water Conservation, Dehradun, India
HS Mishra	
Inder Dev	ICAR-Central Agroforestry Research Institute, Jhansi, India
JC Tewari	ICAR-Central Arid Zone Research Institute, Jodhpur, India
JK Bisht	India
JR Jat	
	Chaudhary Sarwan Kumar Himachal Pradesh Krishi Visvavidyalaya, Palampur, India
Jyotimala Sahu	
K B Sridhar	ICAR-Central Agroforestry Research Institute, Jhansi, India
K Srinivas	
K. Alagusundaram	NRM Division, Indian Council of Agricultural Research, New Delhi, India
K. Patle	
Kavita Satyawali	Pantnagar, India

Kaushal K Garg	International Crop Research Institute for Semi-Arid Tropics, Patancheru, Hyderabad, India
KK Vikrant	Hemvati Nandan Bahuguna Garhwal University, Srinagar, Garhwal, Uttarakhand, India
KN Patel	Sardarkrushinagar Dantiwada Agricultural University, Sardarkrushinagar, Gujarat, India
KS Bangarwa	Chaudhary Charan Singh Haryana Agriculture University Hisar, Haryana, India
KS Verma	Dr. Y.S Parmar University of Horticulture and Forestry, Solan, H.P.
KT Parthiban	Tamil Nadu Agricultural University, Tamil Nadu, India
Lal Chand	ICAR-Central Agroforestry Research Institute, Jhansi, India
LD Koshta	Jawaharlal Nehru Krishi Vishwa Vidyalaya, Jabalpur, Madhya Pradesh, India
Madhulika Srivastava	ICAR-Central Agroforestry Research Institute, Jhansi, India
Mahendra Singh	ICAR-Central Agroforestry Research Institute, Jhansi, India
Manisha Thakur	Dr. Y.S. Parmar University of Horticulture and Forestry, Nauni, Solan, India
Matber Singh	ICAR-National Organic Farming Research Institute, Sikkim, India
Mayank Chaturvedi	ICAR-Central Agroforestry Research Institute, Jhansi, India
Michal V Marek	Global Change Research Institute AS CR, Brno, Czech Republic
ML Sahu	Jawaharlal Nehru Krishi Vishwa Vidyalaya, Jabalpur, Madhya Pradesh, India
MS Pathania	Chaudhary Sarwan Kumar Himachal Pradesh Krishi Visvavidyalaya, Palampur, India
M Ramachandran	Tamil Nadu Veterinary and Animal Sciences University, Kattupakkam, Kancheepuram District, Tamil Nadu, India
Naresh Kumar	ICAR-Central Agroforestry Research Institute, Jhansi, India
Neelam Bisen	Institute of Agricultural Sciences, B.H.U. Varanasi. U.P., India
Neema Bisht	Govind Ballabh Pant University of Agriculture and Technology, Pantnagar, India
Neeraj	N. D. University of Agriculture and Technology, Kumarganj, Faizabad, India
NS Thakur	Navsari Agricultural University, Navsari, Gujarat, India
O.P. Chaturvedi	ICAR-Central Agroforestry Research Institute, Jhansi, India
OP Rao	N. D. University of Agriculture and Technology, Kumarganj, Faizabad, India
OP Yadav	ICAR-Central Arid Zone Research Institute, Jodhpur, India
P.K. Ghosh	ICAR – Indian Grassland and Fodder Research Institute, Jhansi, India
P.K. Mishra	ICAR-Indian Institute of Soil and Water Conservation, Dehradun, India

	ICAR Research Complex, Patna, India
Poornima Malviya	Jawaharlal Nehru Krishi Vishwa Vidyalaya, Jabalpur, Madhya Pradesh, India
	Tamil Nadu Agricultural University, Tamil Nadu, India
Pradyuman Singh	N. D. University of Agriculture and Technology, Kumarganj, Faizabad, India
R. K. Sahu	Jawaharlal Nehru Krishi Vishwa Vidyalaya, Jabalpur, Madhya Pradesh, India
R. M. Singh	Institute of Agricultural Sciences, Banaras Hindu University, Varanasi, India
R.H.Rizvi	ICAR-Central Agroforestry Research Institute, Jhansi, India
Rahul Dongre	Jawaharlal Nehru Krishi Vishwa Vidyalaya, Jabalpur, Madhya Pradesh, India
Rahul Singh	Dr. Y. S. Parmar UHF, Nauni, Himachal Pradesh, India
Rahul Singh	Punjab University Patiala, Punjab, India
Rajesh Kaushal	ICAR-Indian Institute of Soil and Water Conservation, Dehradun, India
Ram Newaj	ICAR-Central Agroforestry Research Institute, Jhansi, India
Ramesh Singh	ICAR-Central Agroforestry Research Institute, Jhansi, India
Raveena Negi	Dr. Y.S. Parmar University of Horticulture and Forestry, Nauni, Solan, India
RC Dhiman	
RK Avasthe	
RK Tewari	ICAR-Central Agroforestry Research Institute, Jhansi, India
RN Sharma	
RP Dwivedi	ICAR-Central Agroforestry Research Institute, Jhansi, India
RP Yadav	India
	Tamil Nadu Veterinary and Animal Sciences University,
	Forest College and Research Institute, Mettupalayam, Coimbatore, TamilNadu, India
S Sarvade	Jawaharlal Nehru Krishi Vishwa Vidyalaya, Jabalpur, Madhya Pradesh, India
	NRM Division, Indian Council of Agricultural Research, New Delhi, India
S.B. Chavan	ICAR-Central Agroforestry Research Institute, Jhansi, India

Salil Tewari	GB Pant University of Agriculture & Technology, Pantnagar, Uttarakhand, India
Sanjeev Kumar	College of Horticulture and Forestry, CAU Pasighat, Arunachal Pradesh, India
SB Agrawal	Jawaharlal Nehru Krishi Vishwa Vidyalaya, Jabalpur, India
Seema Maikhuri	Govind Ballabh Pant University of Agriculture and Technology, Pantnagar, India
SK Chauhan	Punjab Agricultural University, Ludhiana, India
SK Dhyani	NRM Division, Indian Council of Agricultural Research, New Delhi, India
SK Jha	Navsari Agricultural University, Navsari, Gujarat, India
Shishir Kumar Singh	Bundelkhand University, Jhansi, India
SK Verma	N.D. University of Agriculture & Technology, Kumarganj, Faizabad, India
Sourav Gupta	Rajmata Vijayaraje Scindia Krishi Vishwa Vidyalaya, Gwalior, India
SPS Tanwar	ICAR-Central Arid Zone Research Institute, Jodhpur, India
Subrata Sharma	Jawaharlal Nehru Krishi Vishwa Vidyalaya, Jabalpur, Madhya Pradesh, India
Sudhir Kumar	ICAR-Central Agroforestry Research Institute, Jhansi, India
Sumit Chaturvedi	G. B. Pant University of Agriculture & Technology, Pantnagar, Uttarakhand, India
Sushil Yadav	Rajmata Vijayaraje Scindia Krishi Vishwa Vidyalaya, Gwalior, India
T. Thomas	National Institute of Hydrology, Ganga Plains South Regional Centre, WALMI CAMPUS, Bhopal, India
Tarun Kumar	CCS Haryana Agricultural University, Hisar, India
TK Kunhamu	Kerala Agricultural University, Vellanikkara, Thrissur, Kerala, India
US Thakur	Rajmata Vijayaraje Scindia Krishi Vishwa Vidyalaya, Gwalior, India
Usha	RLB Central Agricultural University, Jhansi, India
Varun Attri	Dr. Y. S. Parmar UHF, Nauni, Himachal Pradesh, India
VB Upadhyay	Jawaharlal Nehru Krishi Vishwa Vidyalaya, Jabalpur, Madhya Pradesh, India
Veeresh Kumar	ICAR-Central Agroforestry Research Institute, Jhansi, India
Vikas Kumar	Kerala Agricultural University, Kerala, India
Vikas Kumar	ICAR-Indian Grassland and Fodder Research Institute, Jhansi, India
Vishal Johar	CCS Haryana Agricultural University, Hisar, India



# Contents

<i>Foreword</i>	(v)
<i>Preface</i>	(vii)
<i>Brief Biodata</i>	(viii)
<i>List of Contributors</i>	(xi)
<b>1. Role of agroforestry in current scenario</b>	<b>1–10</b>
— <i>Inder Dev, Asha Ram, S Bhaskar and OP Chaturvedi</i>	
<b>2. Livelihood opportunities through agroforestry interventions</b>	<b>11–22</b>
— <i>K Alagusundaram, SK Dhyani and S Bhaskar</i>	
<b>3. Agroforestry for sustainable land use</b>	<b>23–36</b>
— <i>R Kaushal PK Mishra and H Mehta</i>	
<b>4. Augmenting grasslands and agroforestry for sustaining forage production</b>	<b>37–52</b>
— <i>PK Ghosh and DR Palsaniya</i>	
<b>5. Resource conservation based climate resilient agroforestry system</b>	<b>53–64</b>
— <i>Dhiraj Kumar, Inder Dev, Asha Ram, Ramesh Singh, A.R. Uthappa, K B Sridhar, VeereshKumar, Mahendra Singh, Naresh Kumar, Ram Newaj, Sudhir Kumar, Lal Chand and OP Chaturvedi</i>	
<b>6. Fodder tree based agroforestry systems in hills of Uttarakhand</b>	<b>65–82</b>
— <i>A Pattanayak, JK Bisht, RP Yadav and BM Pandey</i>	
<b>7. Agroforestry systems in hot arid region of India</b>	<b>83–106</b>
— <i>JC Tewari, SPS Tanwar and OP Yadav</i>	
<b>8. Prospects of organic farming in hill agroforestry systems reference to Sikkim Himalayas with specific</b>	<b>107–116</b>
— <i>RK Avasthe, Matber Singh and Ashish Yadav</i>	
<b>9. Role of Wood based Industries in Promotion of Agroforestry and Production of Quality Planting Material</b>	<b>117–130</b>
— <i>RC Dhiman</i>	
<b>10. Potential of short rotation forestry and agroforestry for climate change mitigation and sustainability</b>	<b>131–144</b>
— <i>Abhishek M Tripathi, Radek Pokorny, Vikas Kumar, SK Chauhan, Michal V Marek</i>	

- 11. Biomass production and carbon sequestration potential under different land use systems of western Himalaya** 145–152  
—*Sanjeev Kumar, BP Mishra, KS Verma, Naresh Kumar and AK Handa*
- 12. Carbon sequestration potential of fast growing short rotation tree species based agroforestry systems in Terai Region of Central Himalaya** 153–166  
—*S Sarvade, HS Mishra, Rajesh Kaushal, Sumit Chaturvedi, Rahul Singh, Chaman Lal and Varun Attri*
- 13. Carbon sequestration potential and economics of *Dalbergia sissoo* + paddy based agroforestry system** 167–170  
—*Subrata Sharma, Poornima Malviya, ML Sahu and LD Koshta*
- 14. Biomass carbon potential in agroforestry systems along altitudes in Tehri district of Uttarakhand** 171–178  
—*KK Vikrant, DS Chauhan and RH Rizvi*
- 15. Carbon sequestration potential of few selected tree species** 179–184  
—*AR Manju Hashini, A Balasubramanian, S Radhakrishnan and B Palanikumar*
- 16. Biomass and carbon stock under high density spacings of different tree species** 185–198  
—*Kavita Satyawali, Sumit Chaturvedi, Neema Bisht, Seema Maikhuri, Salil Tewari, Rajesh Kaushal*
- 17. Climate change and adaptation in agriculture: A study of Himachal Pradesh** 199–208  
—*MS Pathania, JS Guleria, Inder Dev and Babli Joshi*
- 18. Agroforestry systems for climate change adaptation and mitigation: A review** 209–226  
—*Sourav Gupta, Jyotimala Sahu, RN Sharma, US Thakur, Sushil Yadav and BS Kasana*
- 19. Growth, biomass production and CO<sub>2</sub> sequestration of some important multipurpose trees under rainfed condition** 227–232  
—*KN Patel, RR Shakhela and JR Jat*
- 20. Biomass production and CO<sub>2</sub> mitigation potential under different land use systems** 233–240  
—*CP Rahangdale, LD Koshta, Neelam Bisen, K Patle and Rahul Dongre*
- 21. Improved livelihood and eco-system services through agroforestry based watershed interventions in Bundelkhand region of central India** 241–250  
—*Ramesh Singh, Inder Dev, RK Tewari, RH Rizvi, Kaushal K Garg, Anand Kumar Singh, RP Dwivedi, KB Sridhar, Mahendra Singh, Dhiraj Kumar, PK Sarkar and OP Chaturvedi*
- 22. Groundwater drought study of Bearma basin in Bundelkhand region using Groundwater Drought Index** 251–266  
—*Dinesh Kumar, T Thomas and RM Singh*

<b>23. DNRA in agroforest soils: A tool for cleaner environment</b>	<b>267–274</b>
— <i>CB Pandey</i>	
<b>24. Agroforestry and soil health: An overview</b>	<b>275–298</b>
— <i>S Sarvade VB Upadhyay, RK Sahu, Atul Shrivastava, Rajesh Kaushal, Rahul Singh and AG Yewale</i>	
<b>25. Potential of bamboos for livelihood and income generation</b>	<b>299–308</b>
— <i>Salil Tewari</i>	
<b>26. Agroforestry for diversification through Livestock</b>	<b>309–318</b>
— <i>M Ramachandran</i>	
<b>27. Performance of ginger and chittaratha under varying spacings of seven year old bamboo (<i>Dendrocalamus strictus</i> (Roxb.) Nees) in central Kerala, India</b>	<b>319–326</b>
— <i>BH Kittur, K Sudhakara, BM Kumar and TK Kunhamu</i>	
<b>28. Performance of wheat and paddy intercropped under poplar (<i>Populus deltoides</i> Bartr. ex Marsh) based agrisilviculture system</b>	<b>327–334</b>
— <i>Pradyuman Singh, OP Rao, KS Bangarwa and Neeraj</i>	
<b>29. Growth performance, essential oil recovery and financial flows of <i>Ocimum</i> spp. under <i>Pongamia pinnata</i> - <i>Ocimum</i> spp. based silvi-medicinal agroforestry systems</b>	<b>335–344</b>
— <i>NS Thakur, Anil Kumar, H Suvera, SK Jha and DB Patel</i>	
<b>30. Quality fodder production through silvo-pastoral system: A review</b>	<b>345–360</b>
— <i>S Sarvade, VB Upadhyay and SB Agrawal</i>	
<b>31. Growth attributes, litter decomposition of certain <i>Populus deltoides</i> Bartr. Ex. Marsh. (poplar) clones and yield performance of paddy and wheat in partially reclaimed sodic soils</b>	<b>361–370</b>
— <i>AK Singh Parihar, SK Verma and OP Rao</i>	
<b>32. Ecologically based pest management for sustainable agroecosystem</b>	<b>371–390</b>
— <i>Madhulika Srivastava, VeereshKumar, Usha, Anil Kumar, Inder Dev, Asha Ram, Naresh Kumar, Dhiraj Kumar, Lal Chand and OP Chaturvedi</i>	
<b>33. Clonal propagation of Eucalyptus using mini cuttings</b>	<b>391–398</b>
— <i>K Srinivas and DSN Raju</i>	
<b>34. Genetic diversity studies on <i>Calophyllum inophyllum</i> (Undi) progenies through Inter simple sequence Repeat (ISSR) markers</b>	<b>399–406</b>
— <i>B Palanikumar, KT Parthiban, PR Renganayaki and C Cinthia fernandaz</i>	
<b>35. Standardization of growing medium and container type for quality stock production of <i>Emblca officinalis</i> Gaertn</b>	<b>407–414</b>
— <i>Raveena Negi, Manisha Thakur and G S Shamet</i>	
<b>36. Effect of anthracnose disease on photosynthetic traits in groundnut (<i>Arachis hypogaea</i>)</b>	<b>415–424</b>
— <i>Ankur Jha, Mayank Chaturvedi, Badre Alam and Ram Newaj</i>	

- 37. Silvipasture model of agroforestry in augmenting fodder production for sustainable livestock farming** **425–432**  
—*S Gunasekaran, C Valli and C Bandeswaran*
- 38. Policy linkages for scaling-up agroforestry in India** **433–442**  
—*Mahendra Singh, KB Sridhar, Dhiraj Kumar, Vikas Kumar, SK Singh, RP Dwivedi, Inder Dev, RK Tewari, and OP Chaturvedi*