



SPRINGER NATURE  
Sustainable Development Goals Series

SDG: 2  
Zero Hunger

A photograph of a red tractor with a yellow tank and a long red spray boom, moving across a green field and spraying a fine mist. The background shows a hazy horizon with some distant buildings.

Jagadish Timsina · Tek N. Maraseni ·  
Devendra Gauchan · Jagannath Adhikari ·  
Hemant Ojha *Editors*

# Agriculture, Natural Resources and Food Security

Lessons from Nepal

 Springer

---

## **Sustainable Development Goals Series**

The **Sustainable Development Goals Series** is Springer Nature's inaugural cross-imprint book series that addresses and supports the United Nations' seventeen Sustainable Development Goals. The series fosters comprehensive research focused on these global targets and endeavours to address some of society's greatest grand challenges. The SDGs are inherently multidisciplinary, and they bring people working across different fields together and working towards a common goal. In this spirit, the Sustainable Development Goals series is the first at Springer Nature to publish books under both the Springer and Palgrave Macmillan imprints, bringing the strengths of our imprints together.

The Sustainable Development Goals Series is organized into eighteen subseries: one subseries based around each of the seventeen respective Sustainable Development Goals, and an eighteenth subseries, "Connecting the Goals," which serves as a home for volumes addressing multiple goals or studying the SDGs as a whole. Each subseries is guided by an expert Subseries Advisor with years or decades of experience studying and addressing core components of their respective Goal.

The SDG Series has a remit as broad as the SDGs themselves, and contributions are welcome from scientists, academics, policymakers, and researchers working in fields related to any of the seventeen goals. If you are interested in contributing a monograph or curated volume to the series, please contact the Publishers: Zachary Romano [Springer; [zachary.romano@springer.com](mailto:zachary.romano@springer.com)] and Rachael Ballard [Palgrave Macmillan; [rachael.ballard@palgrave.com](mailto:rachael.ballard@palgrave.com)].

---

Jagadish Timsina • Tek N. Maraseni •  
Devendra Gauchan •  
Jagannath Adhikari • Hemant Ojha  
Editors

# Agriculture, Natural Resources and Food Security

Lessons from Nepal



### *Editors*

Jagadish Timsina (Editor-in-Chief)  
Institute for Study and  
Development Worldwide  
Sydney, Australia

Global Evergreening Alliance  
Melbourne, VIC, Australia

Devendra Gauchan  
Bioversity International, Nepal  
Kathmandu, Nepal

Tek N. Maraseni  
Center for Sustainable  
Agricultural Systems, ILSE  
University of Southern Queensland  
Toowoomba, QLD, Australia

Jagannath Adhikari  
Adjunct Faculty  
Curtin University  
Eden Hill, WA, Australia

Hemant Ojha  
Institute for Study and Development  
Worldwide  
Sydney, Australia

University of Canberra  
Canberra, ACT, Australia

ISSN 2523-3084

ISSN 2523-3092 (electronic)

Sustainable Development Goals Series

ISBN 978-3-031-09554-2

ISBN 978-3-031-09555-9 (eBook)

<https://doi.org/10.1007/978-3-031-09555-9>

Color wheel and icons: From <https://www.un.org/sustainabledevelopment/>, Copyright © 2020 United Nations. Used with the permission of the United Nations. The content of this publication has not been approved by the United Nations and does not reflect the views of the United Nations or its officials or Member States.

© The Editor(s) (if applicable) and The Author(s), under exclusive license to Springer Nature Switzerland AG 2022, corrected publication 2022

This work is subject to copyright. All rights are solely and exclusively licensed by the Publisher, whether the whole or part of the material is concerned, specifically the rights of translation, reprinting, reuse of illustrations, recitation, broadcasting, reproduction on microfilms or in any other physical way, and transmission or information storage and retrieval, electronic adaptation, computer software, or by similar or dissimilar methodology now known or hereafter developed. The use of general descriptive names, registered names, trademarks, service marks, etc. in this publication does not imply, even in the absence of a specific statement, that such names are exempt from the relevant protective laws and regulations and therefore free for general use.

The publisher, the authors, and the editors are safe to assume that the advice and information in this book are believed to be true and accurate at the date of publication. Neither the publisher nor the authors or the editors give a warranty, expressed or implied, with respect to the material contained herein or for any errors or omissions that may have been made. The publisher remains neutral with regard to jurisdictional claims in published maps and institutional affiliations.

This Springer imprint is published by the registered company Springer Nature Switzerland AG  
The registered company address is: Gewerbestrasse 11, 6330 Cham, Switzerland

---

## Foreword by John Dixon

Nepal is a land-locked country of immense diversity, ecologically and ethnographically. The hills and mountains of the Himalayas dominate the landscape, so that average altitude exceeds all countries in the world except nearby Bhutan. A narrow east-west strip of lowland Terai divides the Nepalese Hills from the Ganges floodplains of India. The dissected landscape and limited infrastructure are major constraints to, but simultaneously opportunities for, sustainable development. The remoteness, diversity, dynamics, and integration of many of the farming and food systems of Nepal have been a severe challenge to researchers and policy makers for many decades. The livelihoods of Nepalese farm families are in transition and depend on four evolving pillars: available natural resources; the management of interdependent crops, livestock, and forests; linkages to value chains; and off-farm income from local, regional, or international work. Cereals, especially rice, wheat, maize, millet, and barley, underpin dietary energy consumption for farmers and city-dwellers alike, increasingly supplemented by vegetables, milk products, eggs, and meat. Today, livestock—cattle, sheep, goats, and yaks—plays important roles in human nutrition and cash income. Their traditional functions as sources of manure for plant nutrition and draft power for ground preparation, threshing, and transportation are being replaced by mechanization. Forests provide fuelwood, timber, fodder, leaf litter, and ecosystem services. The use of external inputs such as seed, fertilizer, feed, and seedlings is low by Asian standards, yet growing as infrastructure and market systems develop. Farming system productivity is also lower than many Asian countries, and slow growth is a challenge for household and national food security. In fact, the national food system has increasing dependence on cereal imports.

Planners often distinguish three broad farming and food systems in Nepal—the lowland Terai, the mid-Hills, and the high Mountain systems. Typically, the lowland Terai systems have larger average farm sizes (although still small), more irrigation, and better access to input and produce markets, including the mega-markets of neighboring India—and good potential for crop intensification and diversification. The Hill farming and food system features strong crop–livestock–forest linkages and strong social capital which are both weakening as population pressure grows and market access improves, especially in districts close to cities or with well-organized value chains for milk or horticultural produce, e.g., orange. Off-farm income has grown in importance for rural livelihoods and farm investment. The

mountain farming system features even stronger population pressure on limited cultivated land and features a variety of minor food crops, potatoes, and grazing yaks, cattle, and their crosses. Tourism is an important source of local income. Both the hill and mountain systems have experienced strong temporary out-migration in search of remittance income as well as permanent relocation to urban centers and the Terai—and growing evidence of abandonment of marginal cropland.

Due to the confluence of ecological and economic characteristics, Nepal has a unique rural development experience from which lessons can be drawn for other small land-locked and mountainous countries around the world. This book, *Agriculture, Natural Resources and Food Security: Lessons from Nepal* is a valuable compendium of rural development knowledge for South Asia and other developing regions of the world. Each of the 24 chapters takes a deep dive on one or another component of the farming and food systems of Nepal. Related to crops, the well-experienced authors document urban agriculture, agro-biodiversity, soil health, pest and disease management, food safety, food production, fruits and vegetables, post-harvest management, citrus production, seed systems, and emerging approaches of conservation agriculture and regenerative agriculture. In relation to animal production, the book analyses livestock development, livestock (and land) ownership, fisheries, and the emerging one-health approach. The role of forestry is examined through the drivers–pressures–states–impacts–responses (DPSIR) framework and the success of community forestry (for which Nepal is famous) leading to emerging thinking on ecosystem services and selective logging policies. The pillars of crops, animals, and forests are tied together through the crosscutting themes of the water–energy–food nexus (as a planning framework), climate-related crop simulation modeling (as a decision support system tool), and a final chapter on gender and adaptation to climate variability. Many of these chapters present analyses of relevant sector and sub-sector trends which point to a mixture of challenges and successes. As in other countries, these agricultural dynamics arise from seven drivers and trends associated with demography, natural resources and climate, knowledge systems and gender, science and technology, markets and infrastructure, and institutions and policies. Overall, the book signals an optimistic view of farming and food systems development in Nepal. In fact, with a recently updated constitution and governance institutions, Nepal looks forward to a vision of achieving the sustainable development goals by 2030 and graduating from the least developed country status to a middle-income developing country soon to create a prosperous and happy Nepal.

Each chapter and the whole book contain development insights in relation to highly constrained smallholder agriculture which are of immense value to researchers and policy makers in Nepal and in other countries with similar situations and farming systems. For example, the successes and challenges of the Nepalese Hill diversified farming system (termed the South Asian Highland Farming System by FAO and the World Bank) are directly relevant to 65 million ha across the South Asian Himalayas from Afghanistan to Myanmar, as well as similar farming systems in east and southeast Asia, Africa, and Latin America. The great potential for integrated farming systems

with effective market access, such as agroforestry systems incorporating trees, crop, and livestock, is emphasized. In a similar fashion, the insights from interlinked agricultural and tourism development in the Nepalese Mountain farming system (termed the South Asian Sparse Farming System) are valuable for 34 million ha across the South Asia region, as well as the high mountains of Africa and Latin America. Of course, these highland and mountain farming systems constitute the water towers which underpin energy and food production for hundreds of millions of lowland populations in South Asia and the rest of the world. In conclusion, the analyses of the rural development experiences in Nepal will be valuable reading for many researchers and policy makers in emerging economies around the world.

John Dixon FTSE  
Adjunct Professor University of Queensland  
Visiting Fellow Australian National University  
Visiting Professor Gansu Agricultural University  
Canberra, Australia

---

## Foreword by Bimala Rai Paudyal

Nepal is one of the richest countries in the world in terms of its incredibly diverse ecology, ecosystems, and biological resources. Human diversity further makes the country rich in knowledge, skills, and capacities. The country is strategically located between two large and rapidly growing economies, namely China and India. However, despite its richness in geographic, environmental, and socio-cultural diversity, the country remains economically poor where poverty, food insecurity, and malnutrition have persisted through time. Agriculture, engaging two-third of labor force, is virtually stagnated with growth rate remaining less than 3% for the past three decades. Its share to the economy is constantly decreasing from 66% in 1970 to 33% in 2010 and 23% in 2020. While food security in Nepal has improved in recent years, the improvement is linked, not to the agriculture production but, to the rapidly growing remittances from overseas migration. About 4.6 million people are still food-insecure, and nearly, half of all children below the age of five are malnourished in the country. Why is there such a wide gap between the potentials and realities?

With the growing realization that food security is intrinsically linked to human and national security, especially in the context of climate crises and geo-political dimensions, recent years have witnessed increasing interest and investment in Nepal from all corners, especially toward innovations, modernization, and expansion of domestic markets in agriculture. The rising demand for homegrown staple food and high-value commodities in domestic and international markets already provides tremendous opportunities for an increased and diversified agricultural production and income. This is an opportune moment to assess and compile good practices, challenges, and opportunities in terms of policies, technologies, extension, and service modalities in such a way that this momentum is capitalized sustainably and equitably.

Although there has been some research and learning documentation on macro- as well as micro-level initiatives to address the policy and knowledge gaps in the sector, the initiatives are scattered and very few come to the notice of dominant policy makers, practitioners, and academics to make an impact. A systematic and comprehensive documentation with professional scrutiny would provide a solid basis for policy makers and practitioners for much-needed improvement needed in the sector. This book, *Agriculture, Natural Resources, and Food Security: Lessons from Nepal* is a product of an enquiry from experts, scientists, academic, researchers, and practitioners that

are multidisciplinary in nature and are interrelated in many ways. The book not only explains the current gaps and explores the potentials in the sectors within the rapidly changing sociopolitical and environmental contexts in Nepal but also showcases practices that can be scaled up throughout the country and beyond. It also provides a useful reference to many other countries in the world that are rich in natural and human resources yet challenged in achieving food security.

Divided into four major parts of interrelated themes, the book provides 24 chapters, and each chapter is rich in content and methodological rigor. Part I—“Agriculture, Horticulture, and Post-harvest management”—highlights a wide range of issues and good practices related to agricultural production and services. Authors outline the potentials of urban agriculture as a model of well-being; advocate for conservation and the use of agro-biodiversity and for improving soil health and security for food security; introduce the concept of plant clinics for better access to crop health services; assess the food production and productivity gap; highlight the need for increased investment for production and post-harvest management of fruits and vegetables; importance of strengthening national seed system and the conservation of agriculture technology. Furthermore, they caution the readers on the growing risks of toxins, contaminants, and adulterants in food and recommend the solution.

In Part II—“Livestock and Fisheries”—authors highlight the contribution of livestock and importance of land and livestock ownership for food security in Nepal and point out constraints, gaps, and opportunities for livestock development; explore the contribution of fishery in the economy; emphasize the interconnectedness of animal–human–environmental health in the context of the COVID-19 pandemic and introduce the “One Health” approach for more collaborative, multidisciplinary, and multi-sectoral solution. Furthermore, the authors introduce a comprehensive framework (DPSIR) to analyze the socio-ecological impacts of transhumance system. Part III—“Forestry, Community Forestry, and Agroforestry”—provides insightful reflections on the potentials of agroforestry becoming an alternative to crop-focused farming and assesses the implications of logging policies and practices on livelihoods. Drawing on lessons from community forestry management, they further assess the potential of an ecosystem-centered approach for local livelihoods and suggest a way forward for a wide and sustainable impact.

In the final part—“Cross Cutting Topics”—authors introduce the W-E-F nexus approach to policy planning and development for sustainable and equitable water, energy, and food security. The potential of crop simulation models to increase food security is explored in the context of changing climate. The final chapter acknowledges the importance of gender roles and relations and examines the interplay between gender equity and adaptation in the Nepalese Himalayas. Increasing feminization of agricultural works on the one hand and widening gender disparities in access to and control over information, technologies, and services on the other requires more dedicated investigation on gender barriers, opportunities, and implications. More importantly, because of direct exposure to nature and greater dependency to perform gender roles, women hold vast knowledge, skills, and capacity for

conservation and sustainable management of natural resources. Such assets need to be valued, protected, enhanced, and promoted for replication/adoption at a wider scale. I believe that the next volume of the book or similar work would shed more light on this often neglected, yet critically important aspect.

I am truly honored to have been one of the first-round readers of such a rich book and for having an opportunity to introduce the book to other readers. I congratulate the authors and the editors for this successful endeavor. I believe the book meets the thirst and hunger of those looking for knowledge, evidence, and sectoral analysis to improve agriculture production and food security in Nepal and beyond.

Thank you.

Bimala Rai Paudyal Ph.D.  
Development Studies Researcher, Member of Parliament  
Federal Parliament of Nepal  
Kathmandu, Nepal

---

## Preface

We, in this editorial team, have spent 20–40 years researching on Nepal's agriculture, natural resources, and environment, which form the backbone of Nepalese economy, local livelihoods, and sustainable development. While people and environment have lived together over the millennia in this Himalayan nation, every time we plan our new research, we notice issues of concerns in these sectors. The past decade has been particularly unprecedented, leaving us intrigued and perplexed, as we see the country become a net food importer from a food exporter. The country remains food-insecure, with more than 15% (4.6 million) people experiencing food access problem. Immediate causes are obvious: limited agricultural productivity, low-value addition, and increasing conversion of fertile agricultural land into settlements and other non-agricultural uses, and so on, but there are also deeper level dynamics which are behind these issues. Productive agricultural lands are being abandoned, while food demand is growing. Land, forest, and natural resources are underutilized while a large proportion of youths migrate to other countries for menial jobs to send money back home so families can buy imported food. Forest area has increased while harvests are restricted, despite known sustainable harvesting technologies. Some technological advances in agriculture are emerging, but social and environmental costs of modernization have been ignored. Research and development work is highly fragmented across sectors ignoring the system-wide dynamics.

These concerns have been the seedbed for the germination of this book. While these concerns animated our collective work, our rich experience and research network provided the confidence to embark on this project. We have had the opportunity to analyze various facets of Nepal's problems and opportunities from various disciplinary angles, from Nepal as well as from Australia, where four of us have been living and working for years. We have worked from within Nepal as well as from outside and have active research projects during the production of this book. Over 60 researchers and experts who joined us as contributors to this volume bring unparalleled insights into why Nepal is facing such challenges and how these can be tackled. All this experience put us in the unique position to explain Nepal's agriculture and environment sector and identify emerging and potential solutions to make Nepal food secure and environmentally sustainable.



This book emerged out of our collaborative work at the Nepalese Association of Agriculture, Forestry and Environment in Australia (NEPAFE), which was set up in early 2019 with a goal to advance scientific cooperation between Nepal and Australia in the agriculture and environmental sectors. NEPAFE provided an excellent platform for us to come together and share our concerns and visions. As members of NEPAFE, we decided that compiling cutting-edge research in the form of an edited volume could be an important contribution to policy and practice. The idea was endorsed and supported by the NEPAFE community, and the editorial group was formed to take the project forward. We then approached Springer with a proposal and book outline which was accepted.

The book takes an integrated and cross-sectoral approach to diagnose problems and identify opportunities. It takes an interdisciplinary approach in presenting the research and practice-based knowledge. We focus on presenting the realities of Nepal while also connecting to wider literature on the diverse topics. This way, our aim has been to identify lessons for Nepal as well as similar developing and mountainous countries in South Asia and the Global South. We believe this book is particularly unique on two counts. First, it covers multiple sectors. Second, it taps into the knowledge of those researchers who have good understanding of the local practical contexts.

Overall, this book showcases recent studies and experimental insights of authors who are actively engaged in Nepal's agriculture and natural resources management policy and practice. Chapters in the book demonstrate how various components of the food systems based on agriculture, livestock, and forestry systems have been researched and managed providing foundations for food systems innovations and how they contribute to achieving various United Nations Sustainable Development Goals (SDGs). Some crosscutting chapters explore gender and climate adaptation, nexus approach to research, development and policy, and application of crop simulation models in research and policy practices and decisions. The book features some of the internationally acclaimed practices with a potential to make significant contributions to food, nutrition, and livelihood security. Overall, the book has investigated why Nepal is facing an increasing level of food insecurity, despite having rich natural resources and explored opportunities for improvement.

The whole work of writing and editing of this book happened at a challenging time. Like with many other things, the COVID-19 pandemic made it difficult to have face-to-face interactions, but also enabled us to see the effects of such crises in Nepal's food system. The cooperation of the chapter authors has been extraordinary, making it possible for us to deliver the manuscript on time to Springer. We thank authors for their willingness to contribute and commitment to revise the paper multiple times in response to the reviewer feedbacks. We have been greatly benefitted by the work of over 40 reviewers who provided critical and constructive comments on the drafts, in some cases needing reviews of multiple versions. We are equally grateful to the publisher

for a timely publication and providing useful feedback on the initial proposal. We hope this book will contribute to scientific and policy debate around effectively managing agriculture, natural resources, and environment in Nepal as well as similar countries around the world.

Melbourne, Australia

Jagadish Timsina  
(Editor-in-Chief)

Sydney, Australia

Hemant Ojha

Toowoomba, Australia

Tek N. Maraseni

Kathmandu, Nepal

Devendra Gauchan

Perth, Australia

Jagannath Adhikari

---

## Reviewers

1. Dr. Shanta Karki, Department of Agriculture, Ministry of Agriculture and Livestock Development, Harihar Bhawan, Lalitpur, Nepal
2. Dr. Umed Pun, Department of Horticulture, School of Natural Resource Management, Njala University, Freetown, Sierra Leone
3. Dr. Govind Ajit, International Center for Agricultural Research in the Dry Areas (ICARDA), Lebanon
4. Dr. Prakash Jha, Kansas State University, Manhattan, Kansas, USA
5. Dr. Pashupati Chaudhary, Asian Disaster Preparedness Centre (ADPC), Phayathai, Bangkok 10400, Thailand
6. Dr. Xuan Li, FAO, Asia-Pacific Regional Office, Bangkok, Thailand
7. Dr. Anant P. Regmi, Former NARC Senior Scientist, NARC, Khumaltar, Lalitpur, Nepal
8. Dr. Krishna Devkota, African Sustainable Agriculture Research Institute (ASARI), Mohammed VI Polytechnic University (UM6P), Laâyoune, Morocco
9. Dr. Sunder Tiwari, Agriculture and Forestry University, Rampur, Chitwan, Nepal
10. Dr. Hira Kaji Manandhar, Executive Chairman, Nepal Plant Disease and Agro Associates (NPDA), Balaju-Chakrapath, Kathmandu, Nepal
11. Dr. Peetambar Dahal, Seed Scientist (Retd.), University of California, Davis, USA
12. Dr. Krishna Prasad Pant, former Joint Secretary, MoALD, Kathmandu, Nepal.
13. Dr. Ganesh Thapa, Board Member, Asia Pacific Agricultural Policy Forum, Seoul, Korea, and former Regional Economist, IFAD, Rome, Italy
14. Dr. Dilip Panthi, North Carolina State University, 455 Research Dr., Mills River, NC 28759, USA
15. Dr. Yakindra Prasad Timilsena, Nourish Nation Foundation, Melbourne, Australia
16. Dr. Durga Mani Gautam, Postharvest Horticulture, Agricultural and Forestry University, Rampur, Chitwan, Nepal
17. Dr. Rajendra Adhikari, The University of Queensland, Gatton Campus, Gatton QLD 4343, Australia

18. Dr. Hum Nath Bhandari, International Rice Research Institute, Bangladesh Office, Dhaka, Bangladesh
19. Dr. Shrawan Kumar Saha, Agricultural and Forestry University, Rampur, Chitwan, Nepal
20. Dr. Jiban Shrestha, Agriculture Botany Division, Nepal Agricultural Research Council (NARC), Khumaltar, Lalitpur, Nepal
21. Dr. Nirajan Bhattarai, Faculty of Animal Science, Veterinary Science and Fisheries, Agricultural and Forestry University, Rampur, Chitwan, Nepal
22. Dr. Prem Bhandari, Adjunct Professor, Agriculture and Forestry University, Nepal; Affiliated Faculty, University of Michigan, USA
23. Dr. Krishna Timsina, National Agricultural Policy Research Centre, NARC, Khumaltar, Lalitpur, Nepal
24. Dr. Tek Bahadur Gurung, Fisheries Program, Agricultural and Forestry University, Rampur, Chitwan, Nepal
25. Dr. Jharendu Pant, World Fish Centre, Penang, Malaysia
26. Dr. Krishna Kafle, Institute of Agricultural and Animal Sciences, Paklihawa Campus, TU, Bhairahawa, Nepal
27. Dr. Doj Raj Khanal, National Animal Health Research Centre, NARC, PO Box 3733, Kathmandu
28. Dr. Uma Karki, Cooperative Extension and Department of Agricultural and Environmental Sciences, College of Agriculture, Environment and Nutrition Sciences, Tuskegee University, Tuskegee, Alabama, USA
29. Dr. Ram Prasad Acharya, University of Southern Queensland, Toowoomba, Queensland, Australia
30. Dr. Thakur Bhattarai, Central Queensland University, Ibis Avenue, North Rockhampton, Queensland 4701
31. Dr. Bharat Pokhrel, Helvetas Swiss Intercooperation, Dhobighat, Lalitpur, GPO Box 688, Kathmandu, Nepal
32. Dr. Bimala Rai Paudyal, Member National Assembly, Federal Parliament of Nepal, Kathmandu, Nepal
33. Dr. Abid Hussain, International Center for Integrated Mountain Development (ICIMOD), Kathmandu, Nepal
34. Dr. Fay Rola-Rubzen, Associate Professor, School of Agriculture and Environment, The University of Western Australia, M087, Perth, WA 6009, Australia
35. Dr. Balaram Thapa, Local Initiatives for Biodiversity, Research and Development (LI-BIRD), Gairapatan, Pokhara, Nepal
36. Dr. Kuenga Namgay, Executive Specialist for Livestock Production, Department of Livestock, Ministry of Agriculture and Forests, Thimphu, Bhutan
37. Dr. Milan Shrestha, School of Sustainability, Arizona State University, 800 S Cady Mall, Tempe, Arizona, USA
38. Dr. Utsav Bhattarai, Institute for Life Sciences and the Environment, University of Southern Queensland, Toowoomba, Queensland, Australia

- 
39. Dr. Rajesh Rai, Professor, School of Forestry and Natural Resource Management, Institute of Forestry, Kathmandu University, Pokhara, Nepal
  40. Dr. Bhoj R. Joshi—Former Director (Livestock), National Animal Science Research Institute, NARC, Khumaltar, Lalitpur, Nepal

---

# Contents

<b>1</b>	<b>Introduction and Overview</b> . . . . .	<b>1</b>
	Jagadish Timsina, Tek N. Maraseni, Devendra Gauchan, Jagannath Adhikari, and Hemant Ojha	
<b>Part I Agriculture, Horticulture, and Post-harvest Management</b>		
<b>2</b>	<b>Cereal Demand and Production Projections for 2050: Opportunities for Achieving Food Self-Sufficiency in Nepal</b> . . . . .	<b>19</b>
	Devendra Gauchan, Krishna P. Timsina, Samaya Gairhe, Jagadish Timsina, and Krishna D. Joshi	
<b>3</b>	<b>Fruits and Vegetables for Food and Nutrition Security and Income Generation in Nepal</b> . . . . .	<b>37</b>
	Indra R. Pandey, Mohan B. Thapa, and Devendra Gauchan	
<b>4</b>	<b>Potential for Citrus Export from Nepal to Tibet</b> . . . . .	<b>53</b>
	Dipendra Aryal, Phul P. Subedi, Kerry B. Walsh, and Sabnam Shivakoti	
<b>5</b>	<b>Postharvest and Quality Management of Fruits and Vegetables in Nepal</b> . . . . .	<b>69</b>
	Bed P. Khatiwada, Shanta Karki, Purushottam P. Khatiwada, and Kishor C. Dahal	
<b>6</b>	<b>Srengthening National Seed System for Food and Nutrition Security in Nepal</b> . . . . .	<b>83</b>
	Sita R. Ghimire, Hari K. Shrestha, Mahendra P. Khanal, and Kedar N. Adhikari	
<b>7</b>	<b>Agrobiodiversity, and Neglected and Underutilized Species for Food, Nutrition, Livelihood, and Environmental Security in Nepal</b> . . . . .	<b>103</b>
	Bal Krishna Joshi and Devendra Gauchan	
<b>8</b>	<b>Improving Soil Health and Soil Security for Food and Nutrition Security in Nepal</b> . . . . .	<b>121</b>
	Bhaba P. Tripathi, Jagadish Timsina, Shree P. Vista, Yam Kanta Gaihre, and Bhoj R. Sapkota	

<b>9</b>	<b>Plant Clinics for Crop Health and Food Security: Experiences from Nepal</b> .....	<b>145</b>
	Yubak Dhoj G. C., Raj K. Adhikari, Shalik R. Adhikari, and Bed P. Khatiwada	
<b>10</b>	<b>Toxins, Contaminants, and Adulteration in Food: Current Policies and Practices, and Future Strategies for Nepal</b> .....	<b>159</b>
	Bhim Chaulagain, Yakindra P. Timilsena, and Bed P. Khatiwada	
<b>11</b>	<b>Regenerative Agriculture for Sustainable Food Security and Livelihoods in Nepal: A Proposal for Multi-scalar Planning Framework</b> .....	<b>177</b>
	Jagannath Adhikari and Jagadish Timsina	
<b>12</b>	<b>Conservation Agriculture Technologies for Cropping Systems Sustainability and Food and Nutrition Security in Nepal</b> .....	<b>195</b>
	Lal P. Amgain, Krishna P. Devkota, Santosh Marahatta, Tika B. Karki, Sagar Kafle, Puspa R. Dulal, Susmita Subedi, Shikha T. Magar, and Jagadish Timsina	
<b>13</b>	<b>Urban Agriculture as a Wellbeing Approach and Policy Agenda for Nepal</b> .....	<b>221</b>
	Arun Kafle, Baden Myers, Rajendra Adhikari, Santosh Adhikari, Prakash K. Sanjel, and Yadav Padhyoti	

## **Part II Livestock and Fisheries**

<b>14</b>	<b>Livestock Contribution to Food and Nutrition Security in Nepal</b> .....	<b>241</b>
	Shreeram P. Neopane, Bhola S. Shrestha, and Devendra Gauchan	
<b>15</b>	<b>Land and Livestock Ownership and Household Food Security in Nepal</b> .....	<b>259</b>
	Prem Bhandari	
<b>16</b>	<b>Sustainable Livestock Production Safeguarding Animal and Public Health in Post-COVID Nepal</b> .....	<b>279</b>
	Santosh Dhakal and Surendra Karki	
<b>17</b>	<b>Changes in Transhumance Systems in Nepal: Analysing Socio-ecological Impacts Using Driver-Pressure-State-Impact-Response Framework</b> .....	<b>297</b>
	Suman Aryal, Tek N. Maraseni, and Geoff Cockfield	
<b>18</b>	<b>Sustainable Fisheries and Aquaculture for Food and Nutrition Security in Nepal</b> .....	<b>315</b>
	Madhav K. Shrestha, Narayan P. Pandit, and Ram C. Bhujel	

### Part III Forestry, Community Forestry, and Agroforestry

- 19 Ecosystems Services from Community Forestry: Prospects and Challenges for Improving Local Livelihoods in Nepal** ..... 337  
Hemant Ojha, Naya S. Paudel, Jagadish Timsina, Sunita Chaudhary, and Himlal Baral
- 20 An Assessment of Selective Logging Policies and Practices in Nepal** ..... 357  
Bishnu H. Poudyal, Tek N. Maraseni, Suman Aryal, and Geoff Cockfield
- 21 Assessing the Potential of Agroforestry in Nepal: Socio-economic and Environmental Perspectives** ..... 375  
Arun Dhakal, Tek N. Maraseni, and Jagadish Timsina

### Part IV Cross-Cutting Topics

- 22 Achieving Water, Energy, and Food Security in Nepal Through Nexus Approach to Planning and Development** ... 397  
Gopi Upreti, Jagadish Timsina, and Tek N. Maraseni
- 23 Potential of Crop Simulation Models to Increase Food and Nutrition Security Under a Changing Climate in Nepal** ..... 415  
Krishna P. Devkota, Jagadish Timsina, Lal P. Amgain, and Mina Devkota
- 24 Agrobiodiversity Management for Gender-Equitable Adaptation to Climate Change: Investigating the Gendered Roots of Vulnerability in the Nepal Himalayas** ..... 439  
Basundhara Bhattarai
- Correction to: Agriculture, Natural Resources and Food Security** ..... C1  
Jagadish Timsina, Tek N. Maraseni, Devendra Gauchan, Jagannath Adhikari, and Hemant Ojha



---

## Editors and Contributors

---

### About the Editors

**Dr. Jagadish Timsina (Editor-in-Chief)** is a systems agronomist specialising on sustainable crop, soil, nutrient and water management; conservation agriculture; sustainable land management and land restoration practices; participatory farming systems research and extension; climate change in agriculture and forestry systems; agriculture-aquaculture systems and crop and systems modelling. He has diverse experience in agronomic, economic, and environmental management of agro-ecologies ranging from flat lands in Australia to hills and mountains in South and Southeast Asia. He has published more than 200 papers and book chapters with co-authors from more than thirty countries in various peer-reviewed international journals and books, with Google Scholar based h-index of 43 and total citations of 6850. He has worked with University of Melbourne and Commonwealth Scientific and Industrial Research Organization (Australia), International Rice Research Institute (IRRI) and International Maize and Wheat Research Centre (CIMMYT) in Bangladesh and the Philippines, and the Institute of Agriculture and Animal Sciences (Tribhuvan University) and Agricultural and Forestry University in Nepal for over forty years. Currently, he is associated with the Melbourne-based Global Evergreening Alliance and Sydney-based Institute for Study and Development Worldwide (Australia), and works as a consultant with CIMMYT in Bangladesh, WorldFish Center in East Timor and Asian Development Bank Institute in Japan. In the past, he served as an editorial board member of *Field Crops Research Journal* and *Journal of Farming Systems Research and Extension* and as a guest editor of *MDPI's Agronomy Journal*. Currently, he is an editor of the *Agricultural Systems journal* and *Global Journal of Agriculture and Allied Sciences*.

**Prof. Tek Maraseni (Editor)** earned a double B.Sc. (Science and Forestry) in Nepal, an M.Sc. (NRM) in Thailand, where he was awarded a gold medal (GPA 4/4), and a Ph.D. (Environmental Science and Management) in Australia. He has over 26 years of research experience in identifying and adopting management practices that improve productivity, profitability and the sustainability of agriculture and forestry systems whilst reducing greenhouse gas emissions. Over the past 6 years, he has successfully completed multiple research projects in 16 countries. He has co-authored with

researchers from 31 countries and published 4 books, 32 book chapters, one submission to UNFCCC, 5 policy briefs, 25 technical reports, and 174 journal papers. He has supervised 16 Ph.D. students to completion, served as an editorial member for two international journals, and reviewed Ph.D. theses and proposals for granting bodies. His research work has been recognised through several national and international awards and fellowships: (1) US National Science Foundation (NSF) Fellowship in 2009; (2) “Queensland-China Climate Change Fellowship” in 2009; (3) US State Department “Climate Change Professional Fellows” award in 2011; (4) “Visiting Professor for Senior International Scientist” award from the Chinese Academy of Sciences in China (2013-2019); (5) First runner-up award from Elsevier Journal “Environmental Development” in 2015; and (6) University of Southern Queensland (USQ) Research Excellence Award, three times (2009, 2014 and 2021).

**Dr. Devendra Gauchan (Editor)** is an Agricultural Economist with expertise in agrobiodiversity, seed system and food security. He has Ph.D. degree from the University of Birmingham, United Kingdom and has worked as a consultant and expert in various national and international organizations over the past 25 years. He is currently the Honorary Research Fellow at the Alliance of Bioversity International and International Centre for Tropical Agriculture (CIAT), and serves as the Regional Officer South Asia and Research Advisor in Agricultural Economics at Platform for Agrobiodiversity Research (PAR), Rome, Italy. He is an Adjunct Professor at the Institute of Agriculture and Animal Sciences (IAAS), Tribhuvan University, Kathmandu. He was the National Project Manager of Bioversity International led projects in Nepal from 2015–2020. Previously, he was the Head of Socioeconomics and Agricultural Research Policy Division at Nepal Agricultural Research Council (NARC) Kathmandu. During his tenure at NARC, he played instrumental role in bringing social sciences dimension in agricultural research by establishing and leading Socioeconomic and Policy Research Division. He has also worked as a Post-Doctoral Fellow at the International Rice Research Institute, Philippines carrying out rice socio-economic research activities in South Asia from 2008–2011. He has published several research papers on agriculture and natural resource management in many journals and books.

**Dr. Jagannath Adhikari (Editor)** is a human geographer. He has over 20 years research, teaching and consultancy experiences in various areas of international development—sustainable livelihood; climate change and food security; sustainable agriculture; participatory natural resources management; land management and land reform; agrarian change and livelihoods; globalization, migration, remittances, and development. He worked as a Visiting Professor in Kyoto University (Japan) and as a Visiting Scholar and Research Fellow in Heidelberg University (Germany), The Australian National University (Canberra), University of Sussex (UK), and Worcester Poly-Technique Institute—WPI (USA). Presently, he is affiliated with Curtin University of Technology, Perth, Australia as an adjunct faculty and with

Nepal Institute of Development Studies, Kathmandu, Nepal as a senior researcher. He has authored/co-authored various chapters in over a dozen of books, including a recent Springer book and papers in many journals. He is one of the editors of Journal *European Bulletin of Himalayan Research* and was a guest editor of *Journal of Forestry and Livelihood* for its special issue on sustainable agriculture.

**Dr. Hemant Ojha (Editor)** works partly as an Associate Professor for University of Canberra and partly as a Principal Advisor for the Institute for Study and Development Worldwide (IFSD). His work focusses on understanding and catalysing multi-scalar environmental governance in a way that supports community empowerment and climate resilience, and he pursues this goal by combining political economy and critical policy analysis with action research. From his early career work in the Himalayan South Asia, his work has expanded to Asia and the Pacific as well as parts of Africa. His critical policy analysis and action research has greatly influenced the development of Nepal's community forestry system, which is seen as one of the few global successes in community based environmental management. From Australia, his past 10 years of work in Asia and the Pacific has focussed on exploring policy and action-oriented solutions for climate resilience and inclusive environmental governance. He has also served as a lead author for several international environmental assessments, including a recent Himalayan regional assessment of environmental governance, supported by multiple OECD members. In his current action research, he is testing methodologies for fostering co-production of science, policy and practice in water and agri-food sectors for various contexts. He has published widely on climate change, environmental policy, and international development, and sits on the editorial boards of several international journals.

---

## Contributors

**Jagannath Adhikari** School of Humanities, Curtin University, Perth, Australia

**Kedar N. Adhikari** The University of Sydney, IA Watson Grains Research Centre, Narrabri, NSW, Australia

**Raj K. Adhikari** Himalayan College of Agricultural Science and Technology (HICAST), Kathmandu, Nepal

**Rajendra Adhikari** The University of Queensland, Gatton, QLD, Australia

**Santosh Adhikari** The University of Tasmania, Hobart, TAS, Australia

**Shalik R. Adhikari** Department of Agriculture, Gandaki Province Government, Agriculture Knowledge Centre, Kaski, Nepal

**Lal P. Amgain** Faculty of Agriculture, Far-Western University, Tikapur, Kailali, Nepal;  
Institute of Agriculture and Animal Sciences, Tribhuvan University, Kathmandu, Nepal

**Dipendra Aryal** Central Queensland University (CQU), Rokhampton, QLD, Australia

**Suman Aryal** Centre for Sustainable Agricultural Systems, University of Southern Queensland, Toowoomba, QLD, Australia;  
Siddhartha Environmental Services, Kathmandu, Nepal

**Himal Baral** Center for International Forestry Research (CIFOR), Bogor, Indonesia

**Prem Bhandari** Agriculture and Forestry University, Bharatpur, Nepal;  
University of Michigan, Ann Arbor, MI, USA

**Basundhara Bhattarai** Institute for Study and Development Worldwide (IFSD), Sydney, NSW, Australia

**Ram C. Bhujel** Aqua-Centre, School of Environment, Resources and Development, Asian Institute of Technology, Khlong Nueng, Thailand

**Sunita Chaudhary** International Centre for Integrated Mountain Development, Kathmandu, Nepal

**Bhim Chaulagain** Xarvio Digital Farming Solutions-BASF, Durham, NC, USA

**Geoff Cockfield** Centre for Sustainable Agricultural Systems, University of Southern Queensland, Toowoomba, QLD, Australia

**Kishor C. Dahal** Institute of Agriculture and Animal Science, Tribhuvan University, Kirtipur, Nepal

**Krishna P. Devkota** African Sustainable Agriculture Research Institute (ASARI), Mohammed VI Polytechnic University (UM6P), Laâyoune, Morocco

**Mina Devkota** International Center for Agricultural Research in the Dry Areas (ICARDA), Rabat, Morocco

**Arun Dhakal** Nepal Agroforestry Foundation (NAF), Kathmandu, Nepal

**Santosh Dhakal** W. Harry Feinstone Department of Molecular Microbiology and Immunology, Johns Hopkins Bloomberg School of Public Health, Baltimore, MD, USA

**Puspa R. Dulal** Department of Agronomy, Agriculture and Forestry University, Rampur, Chitwan, Nepal

**Yubak Dhoj G. C.** Food and Agriculture Organization of the United Nations, Regional Agriculture Office, Bangkok, Thailand

**Yam K. Gaihre** International Fertilizer Development Centre (IFDC), Alabama, USA

**Samaya Gairhe** Monitoring and Evaluation Division, Nepal Agricultural Research Council, Kathmandu, Nepal

**Devendra Gauchan** Alliance of Bioversity International and CIAT, Rome and IAAS, Tribhuvan University, Kathmandu, Nepal

**Sita R. Ghimire** Agriculture and Food, Commonwealth Scientific and Industrial Research Organisation (CSIRO), Canberra, Australia

**Bal Krishna Joshi** National Agriculture Genetic Resources Centre, NARC, Khumaltar, Kathmandu, Nepal

**Krishna D. Joshi** International Rice Research Institute (IRRI), Nepal Office, Khumaltar, Lalitpur, Nepal

**Arun Kafle** Sustainable Infrastructure and Resource Management (SIRM), UniSA, STEM, University of South Australia (UniSA), Mawson Lakes Campus, Adelaide, SA, Australia

**Sagar Kafle** CIMMYT, South Asia Regional Office Nepal, Lalitpur, Nepal

**Shanta Karki** Department of Agriculture, Ministry of Agriculture and Livestock Development, Kathmandu, Nepal

**Surendra Karki** Department of Epidemiology and Public Health, Himalayan College of Agricultural Sciences and Technology, Kathmandu, Nepal; Food and Agriculture Organization of the UN, Emergency Center for Transboundary Animal Diseases, Kathmandu, Nepal

**Tika B. Karki** National Agronomy Centre, Nepal Agriculture Research Council, Kathmandu, Nepal

**Mahendra P. Khanal** Knowledge-Based Integrated Sustainable Agriculture in Nepal (KISAN II), Sanepa, Lalitpur, Nepal

**Bed P. Khatiwada** Nourish Nation Foundation, Melbourne, Australia

**Purushottam P. Khatiwada** Value Chain Development of Fruit and Vegetables Project (MoALD/UNDP), United Nations Development Program, Lalitpur, Nepal

**Shikha T. Magar** Department of Crop Production, Faculty of Agronomy, Hebei Agricultural University, Baoding, China

**Santosh Marahatta** Department of Agronomy, Agriculture and Forestry University, Rampur, Chitwan, Nepal

**Tek N. Maraseni** Centre for Sustainable Agricultural Systems, University of Southern Queensland (USQ), Toowoomba, QLD, Australia

**Baden Myers** Australian Flow Management Group and UniSA STEM, Sustainable Infrastructure and Resource Management (SIRM), Mawson Lakes Campus, Adelaide, SA, Australia

**Shreeram P. Neopane** Himalayan College of Agricultural Sciences & Technology (HICAST), Kathmandu, Nepal

**Hemant Ojha** Institute for Study and Development Worldwide (IFSD), Sydney, NSW, Australia;  
University of Canberra, Canberra, ACT, Australia

**Yadav Padhyoti** Ministry of Agriculture and Livestock Development, Kathmandu, Nepal

**Indra R. Pandey** Nepal Horticulture Society, Kathmandu, Nepal

**Narayan P. Pandit** Fisheries Program, Faculty of Animal Science, Veterinary Science and Fisheries, Agriculture and Forestry University, Chitwan, Nepal

**Naya S. Paudel** ForestAction Nepal, Bagdole, Lalitpur, Nepal

**Bishnu H. Poudyal** Forestry and Environmental Science, Natural Resources Management, Climate Change, Ministry of Forests and Environment, Kathmandu, Nepal

**Prakash K. Sanjel** Ministry of Agriculture and Livestock Development, Kathmandu, Nepal

**Bhoj R. Sapkota** Ministry of Agricultural and Livestock Development, Kathmandu, Nepal

**Sabnam Shivakoti** Government of Nepal, Ministry of Agriculture and Livestock Development, Kathmandu, Nepal

**Bhola S. Shrestha** Heifer International Nepal (HIN), Lalitpur, Nepal

**Hari K. Shrestha** International Maize and Wheat Improvement Centre (CIMMYT), South Asia Regional Office, Khumaltar, Lalitpur, Nepal

**Madhav K. Shrestha** Centre for Aquaculture-Agriculture Research and Production, Kathar, Chitwan, Nepal

**Phul P. Subedi** Central Queensland University (CQU), Rockhampton, QLD, Australia

**Susmita Subedi** Department of Agronomy, Agriculture and Forestry University, Rampur, Chitwan, Nepal

**Mohan B. Thapa** Nepal Horticulture Society, Kathmandu, Nepal

**Yakindra P. Timilsena** Nourish Nation Foundation, Melbourne, Australia

**Jagadish Timsina** Global Evergreening Alliance, Burwood East, Melbourne, Victoria, Australia;  
Institute for Study and Development Worldwide (IFSD), Sydney, Australia

**Krishna P. Timsina** National Agricultural Policy Research Centre, NARC, Khumaltar, Lalitpur, Nepal

**Bhaba P. Tripathi** Institute of Agriculture and Animal Sciences (IAAS), Tribhuban University, Kathmandu, Nepal

**Gopi Upreti** Institute of Agriculture and Animal Sciences, Tribhuvan University, Kirtipur, Nepal;  
Senior Data Scientist at ManTech International Corporation, Fairfax, VA, USA

**Shree P. Vista** National Soil Science Research Centre, Nepal Agricultural Research Council (NARC), Lalitpur, Nepal

**Kerry B. Walsh** Central Queensland University (CQU), Rockhampton, QLD, Australia

# Introduction and Overview

# 1

Jagadish Timsina, Tek N. Maraseni,  
Devendra Gauchan, Jagannath Adhikari,  
and Hemant Ojha

## Abstract

This chapter provides an overview of 23 chapters included in the book. The book aims to present recent knowledge on issues and topics related to agriculture, livestock, and forestry systems across the three agroecological regions of Nepal. Chapters in the book are grouped into four themes: (a) Agriculture, horticulture, and post-harvest management;

(b) livestock and fisheries; (c) forest ecosystems, community forestry, and agroforestry, and (d) crosscutting topics. Chapters demonstrate how various components of the food systems—including agronomy, horticulture, agrobiodiversity, soil science, plant health, food toxins and food safety, seed innovation systems, post-harvest management, livestock production, ownership and health, aquaculture and fisheries production, urban agriculture, transhumance systems, and socioeconomics—have been researched and managed to provide foundations for food systems innovations in Nepal. The book also catalogues a wide range of solutions: need of increased investment in R&D to develop new climate resilient technologies and practices and promotion of locally adapted species and varieties for increased and sustained productivity of cereals, fruits, and vegetables, and aquaculture and livestock; development of market linkages with China, India, and other countries; development of robust national seed system; conservation and multiplication of native and neglected species and landraces; effective soil fertility management and soil health improvement; use of plant clinics for pest management; promotion of conservation agriculture and regenerative agriculture practices; promotion of urban agriculture; correcting infective institutional arrangements to minimize food toxins and post-harvest losses; adoption of multisectoral and collaborative one-health

J. Timsina (✉)  
Global Evergreening Alliance, Melbourne, Burwood  
East, VIC 3151, Australia  
e-mail: [timsinaj@hotmail.com](mailto:timsinaj@hotmail.com)

J. Timsina · H. Ojha  
Institute for Study and Development Worldwide,  
Sydney, Australia  
e-mail: [Hemant.ojha@ifsd.com.au](mailto:Hemant.ojha@ifsd.com.au)

T. N. Maraseni  
University of Southern Queensland, Toowoomba,  
QLD, Australia  
e-mail: [Tek.Maraseni@usq.edu.au](mailto:Tek.Maraseni@usq.edu.au)

D. Gauchan  
Alliance of Bioversity International and CIAT,  
Rome and IAAS, Tribhuvan University, Kathmandu,  
Nepal  
e-mail: [d.gauchan@cgiar.org](mailto:d.gauchan@cgiar.org)

J. Adhikari  
School of Humanities, Curtin University, Perth,  
Australia  
e-mail: [Jagannath.adhikari@gmail.com](mailto:Jagannath.adhikari@gmail.com)

H. Ojha  
University of Canberra, Canberra, Australia



approach for integrated animal–human–environmental health; protecting transhumance systems in mountains; integrating ecosystem services in forest and agrobiodiversity management; active harvesting of trees and forest products; promotion of integrated agroforestry systems; managing water–energy–food nexus for research and policy planning and implementation; applications of simulation modelling in closing yield gaps and in climate change studies; and gender and socially inclusive technology development. Whilst these solutions are not entirely new, this book has unravelled why these solutions have not gained traction or how these can be taken forward in more contextually grounded way, not only in Nepal but generally in other countries with similar farming systems and terrestrial environmental issues.

### Keywords

Agrobiodiversity • Agroforestry and community forestry • Conservation and regenerative agriculture • Ecosystems services • Livestock and fishery • Simulation modelling • W–E–F nexus

## 1.1 Background and Rationale

A landlocked country sandwiched between India and China, Nepal is divided into three east–west running agroecological regions or zones. These include: (i) the Terai and Inner Terai in the southern plains that run from the south-east to south-west at elevations typically below 800 m; (ii) the low-, mid- and high-hills in north of Terai and Inner Terai and south of the Himalayan range typically between 800 and 4000 m, and (iii) Himalayan range above 4000 m. Within each of the first two regions, a variety of crops, vegetables and fruits, and tree species are grown, and a range of livestock, poultry and fish species are raised, within an integrated crop-livestock-tree-based system. In the Himalayan region, however, farming (highland crops and livestock grazing) is limited due to extremely low temperatures (Dixon et al. 2001; Krupnik et al.

2021). These agricultural practices are supported by agroecosystems and natural resources which include rich biodiversity, forested landscapes, and abundant water resources.

The agriculture sector in Nepal contributes to about 26% of the national GDP and provides employment to about 60% of the labour force (MoF 2021). Most of the farmers in Nepal are smallholders and poor, and the food they produce is insufficient even for themselves. Nepal remains one of the food insecure countries, with more than 15% (4.6 million) people experiencing food insecurity (USAID 2019). Malnutrition and micronutrient deficiencies amongst children, pregnant, and lactating women are still prevalent, especially in mountainous areas. With current trends of increasing population, decreasing arable land, and low yearly increment in the rate of cereal productivity, Nepal has an annual deficit of >1.3 million tons of edible rice, wheat, and maize (Devkota et al. 2022). Fruits, vegetables, livestock, and fish are also insufficient to meet the demand of ever-increasing population (Neopane et al. 2022; Pandey et al. 2022; Shrestha et al. 2022). Moreover, the agriculture sector in Nepal contributes approximately 50% of the national greenhouse gas (GHG) emissions, rising to 60–70% if multiple points in the food value chains are considered (MOFE 2021). Clearly, increasing productivity and sustainability of agriculture is a major challenge, which is further escalated by increasing GHG emissions from agriculture and global climate change.

Forest and trees are important contributors to the local livelihoods and national economy. Trees grown in the forest or farmlands contribute about 15% of the national GDP and 9.23% of total national employment (World Bank 2016). Forests can protect the environment, provide various kinds of ecosystems services, sequester carbon in soil and biomass, provide timber and non-timber forest products for domestic use and export to other countries, and improve the livelihoods of people living around the forests (Ojha et al. 2022; Poudyal et al. 2022). Agroforestry systems integrating crops, livestock, and trees practised in farmlands in all agroecologies have significant potential to provide all these

benefits to farmers to improve their livelihoods (Dhakal et al. 2022). Whilst technological advancements in agriculture and forestry are important for increasing food productivity and meeting nutritional requirements, there are large socio-economic variations including gender differences, which call for a need to have gender and socially inclusive technology development and farming systems in the country (Bhattarai 2022). These all need to be operated under the nexus approach in policy at the ministerial level and the farming systems approach in research and development at the field level and in the context of global climate change. Application of digital predictive tools such as simulation models for crop yield prediction and decision support systems (DSSs) for crop, nutrient and water management and crop yield prediction and climate forecasting, and adoption of water–energy–food–land nexus as the dominant planning framework would play an important role in future (Amgain et al. 2022; Devkota et al. 2022; Maraseni et al. 2021; Uprety et al. 2022). Hence, the book showcases recent studies and experimental insights of issues on various components of agriculture, forestry and natural resources management and provides concrete research and policy implications and recommendations on the above topics.

## 1.2 Book Structure and Chapter Overview

Chapters in this book are grouped into four themes: Theme 1–Agriculture, horticulture, and post-harvest management (12 chapters); Theme 2–Livestock and fisheries (5 chapters); Theme 3–Forest ecosystems, community forestry, and agroforestry (3 chapters); and Theme 4–Cross-cutting topics (3 chapters). Each theme includes several chapters which highlight recent advances in research and development practices happening in Nepal. Chapters also draw on wider literature, discuss implications for policy and development and provide detailed recommendations for research and policy in Nepal as well as more broadly for South Asia. In this chapter, we offer

theme-wise overview of chapters integrating the knowledge from individual components of agricultural and food systems and provide key research and policy recommendations.

### 1.2.1 Theme 1: Agriculture, Horticulture, and Post-harvest Management

Cereals are a major source of food security, income, livelihood, and employment in Nepal. Gauchan et al. (2022) used compound growth rates and instability index techniques to assess the growth patterns and dynamics of cereal yields, production and import growth, and food demand and self-sufficiency in Nepal. They estimated the cereal production and demand growth and self-sufficiency ratios for 2050 using different scenarios and Auto Regressive regression model to analyse the relationship between domestic production and income growth with import. They found that the current cereal production is low to meet the current and future food demands of the increasing population. They concluded that the country cannot achieve cereal self-sufficiency by 2030 as envisioned by UN's SDGs and even by 2050. Thus, Nepal will continue to import a large quantity of cereals, particularly rice and maize in the foreseeable future.

Fruits and vegetables are rich sources of dietary fibre, vitamins, minerals, electrolytes, phytochemicals, and antioxidants, with high potential for improving food and nutritional security and peoples' livelihoods. Pandey et al. (2022) documented the status of fruits and vegetables research and varieties developed and recommended, and analysed their area, production, and yield growth rates and import and export situation in Nepal. Their findings showed that the development and release of hybrids and open-pollinated varieties using locally adapted genetic resources are limited in fruits and vegetables. They showed that despite the increase in area growth, the production has not increased resulting in rapid imports of fruits and vegetables in recent years to meet the increasing demands.