

PRINCIPLES AND PRACTICES OF FOOD SECURITY

SUSTAINABLE, SUFFICIENT, AND SAFE FOOD FOR HEALTHY LIVING IN NEPAL

Editor-in-Chief
Drona P. Rasali

Co-Editor-in-Chief/Managing Editor
Prem B. Bhandari

Editors
Uma Karki, Megha N. Parajulee,
Ram N. Acharya, and Raju Adhikari



**ASSOCIATION OF NEPALESE AGRICULTURAL
PROFESSIONALS OF AMERICAS (NAPA), USA**

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We would like to express our deepest appreciation to the authors and co-authors, who took seriously the Editorial Board’s call for abstracts, making their best efforts to submit chapters in a timely way, and to revise multiple times as per the comments and feedback provided by the editors and reviewers. Without your determined contribution, this book would not have been possible to publish.

Our reviewers deserve special appreciation for offering their valuable time and expertise unconditionally while meticulously reviewing the chapters assigned to them. All the voluntary contributions made by editors and reviewers is valued in the spirit of diaspora contributions to Nepal as a way to demonstrate their commitment and love to the country, while the scholarly work would be contributing to benefit the global community. The three professionals who helped us check plagiarism in each chapter and language editors who took the responsibility of reading each and every word and edited the language in this book deserve a special mention. Special thank goes to Dr. Bill F. Ndi, Professor of Modern Languages, Creative Writing, and Professional and Technical Communication, and Janet T. Sullen, Language, Art and Science Connections Director, Tuskegee University who managed the tedious task of language editing for the book.

Finally, we, on behalf of NAPA, would like to dedicate the book to the readers and stakeholders and sincerely hope the information is useful to them and wider community.

~Editorial Board

Disclaimer

Ideas and opinions expressed in this book are of authors and do not necessarily reflect the views of the Editorial Board and the Association of Nepalese Agricultural Professionals of Americas (NAPA).

FOREWORD I

Thank you for honoring me with the opportunity to write a foreword for this book entitled, “PRINCIPLES AND PRACTICES OF FOOD SECURITY: Sustainable, Sufficient, and Safe Food for Healthy Living in Nepal.” The topic is relevant and the information provided is timely for a world that is grappling with the challenges of poverty and food insecurity, especially in developing countries. Nepal is not an exception. Importantly, the world population is steadily increasing, and the current nearly 7.8 billion (April 2020) population is expected to grow to 10 billion by 2050. Meanwhile, planet Earth faces the challenge of limited land for agricultural production needed to feed the growing population, including nearly 700 million people still living in extreme poverty and struggling to fulfill their most basic needs.

Food insecurity is multidimensional and adversely influences many aspects of human life. Globally, in 2017, 821 million people were estimated to be undernourished. An increase in food production is an important but not sufficient condition to curb the food insecurity problem. Access to food and its proper utilization in a sustainable way is also necessary. This book focuses on various micro- and macro-level socio-economic factors and agricultural production and productivity in curbing food insecurity in Nepal. The information presented in the book is relevant to many developing countries. The agriculture sector provides livelihoods for 40 percent of today’s global population and is among the largest employers and the main source of income and jobs for rural households. Specific to Nepal, nearly two-thirds of the population still depends on subsistence agriculture, which contributes to about one-third of the total GDP.

The chapters are written by experts/scientists in agricultural and allied disciplines. The authors have both in-country and out-of-country knowledge and experience in the subject matter based on quality research which is highly commendable. Their efforts to contribute to their homeland from the diaspora deserves special mention. I hope this book will generate enough interest and stimulate academic discourse among scholars and students to find evidence-based policies for a country like Nepal to overcome food-insecurity challenges.

Finally, I acknowledge the dynamic leadership of NAPA President, Dr. Lila B. Karki; without his dedication and relentless hard work, NAPA would not have accomplished such an exemplary deed within its first four years of establishment. Equally, I am very happy to have seen Professor Dr. Uma Karki as one of the editors of this book. Both diligent staff members have reflected the contribution of Tuskegee University to the global audience appropriately.

All the best.

Walter A. Hill, Ph.D.
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March 24, 2020



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FOREWORD II

It is a pleasure for me to write a foreword for the book, “PRINCIPLES AND PRACTICES OF FOOD SECURITY: Sustainable, Sufficient, and Safe Food for Healthy Living in Nepal.” The book covers all four pillars of food security including the neo-liberal economic policies and the impact on food security in developing countries like Nepal. It has brought out a wide range of knowledge on diverse aspects of food security and nutrition, while providing the basic ingredients for 'Eradicating Hunger' from the globe by 2030.

Still 820 million people are suffering from hunger around the world. According to the State of Food Security and Nutrition in the World 2019 Report, the largest number of undernourished people (more than 500 million) live in Asia, mostly in South Asian countries. The Global Report on Food Crisis, 2019 reveals that more than 113 million people across 53 countries experienced acute hunger requiring urgent food, nutrition, and livelihoods assistance. Globally, 7.3 percent (49.5 million) children under five years of age are wasted, two-thirds of whom live in Asia. At the same time, no region is exempt from the epidemic of overweight and obesity, which contributes to four million deaths globally.

In Nepal, according to Food and Agriculture Organization (2019), 8.7 percent of the population are undernourished. Most of these people live in small and isolated communities, where food assistance interventions are challenging. The residual effect of the 2015 earthquake that took 9000 lives and devastated the country's infrastructures, economic blockade in the southern border, and transition to federalism have further affected food security situation with much impact on sustainable development. Despite these internal and external factors influencing the current food security situation in Nepal, Right to Food and Food Security has been established as the fundamental rights in the newly crafted federal constitution of Nepal.

The food insecurity has global challenges and generates multiple chain effects in families, society, state, and overall development. Most sufferers are the people from Africa and South Asia due to conflict and insecurity, climate shocks and economic turbulence, the main drivers of food insecurity, which continued to erode livelihoods and destroy lives. Low- and middle-income countries are exposed to external vulnerabilities. As the book also stipulates, neo-liberalization has damaged the local food system and promoted a corporate food regime that created import-based food dependency in developing countries like Nepal. It critically investigates the dimensions of the political economy of food security in Nepal, linking global to the local context.

Ending hunger and all forms of malnutrition by 2030 is an immense challenge ahead. The book has highlighted ways to overcome these challenges with the strategic interventions at various levels. The book reiterates that the zero hunger is achievable with accountable political commitment, transformative interventions, and responsible investments.

I commend the broad food security issues and recommendations raised in this book to a wide global audience. Moreover, it is immensely useful for country's policymaking particularly to the State Government of Karnali, as the state has the highest prevalence of food insecurity. I expect the book stimulates us all who are striving together to leave no one with hunger by 2030. I congratulate and extend my gratitude to the Editor-in-Chief, editorial team, all the associated professionals, and especially NAPA for bringing this important piece of work.

Man Bahadur Bk, Ph.D.
Secretary

Preface

Greetings ALL!

Food security is a global problem. According to WHO, over 2 billion people, mostly in low- and middle-income countries, do not have regular access to safe, nutritious, and enough food. An estimated 821.6 million people (or 1 in 9 people) did not have enough to eat in 2018, up from 811 million in the previous year, which is the third year of increase in a row. Of which, 513.9 million were in Asia, and 256.1 million were in Africa. Globally, the number of moderately or severely food insecure people were 2 billion (26.4%) in 2018. Together, Africa and Asia bear the most considerable share of all forms of malnutrition, accounting for more than nine out of ten of all stunted children worldwide. In southern Asia and sub-Saharan Africa, one in three children is stunted, where subsistence agriculture has been a significant source of livelihood for many. These daunting facts call for a profound transformation of agriculture to provide access to food to everyone as a universal human right.

A vast majority of farmers across the globe are small-scale producers. Thus, food security has been a critical challenge for them. Moreover, ever-increasing mechanization and costlier technologies have further exacerbated their capacity to increase food production and productivity, access to enough and safe food for a healthy living. All institutions and individuals working in agricultural and allied sectors should endeavor further as the large portion of our global population dreaming of a full-stomach two-meals a day is ever increasing. It is an undeniable fact that agriculture is the largest sector that produces and provides living creatures with food to survive regardless of their social status and geographic location where they live. Considering this factual truth, NAPA set her priority agenda from DAY one to securing food, feed, fuel, and fiber (F4) for the ever-increasing population through agricultural innovations, best management practices, safeguarding the environment, and cost-friendly technology, and sustainable agricultural production systems. Accordingly, NAPA adopted a long-range perspective theme, **Global Food Security through Agricultural Transformation**, using appropriate, farmer-friendly, and situation-specific technologies as a priority goal.

This book is a product of NAPA's long-envisioned goal. The plan to publish this book by a nascent professional organization that was instituted four year ago per se was apparently a big dream. The relentless hard work, dedication, and commitment of the editorial board, specifically by Prem Bhandari, Co-Editor-in-Chief, and the NAPA executive committee, brought this to fruition – nothing is impossible if we have a steadfast willpower. This book is a witness of NAPA's unwavering mission to underpin that 'access to food is a universal human right to sustain a healthy life.' Willingness to contribute a chapter was pouring in upon our call for a chapter contribution from professional members and beyond. On behalf of the NAPA community, I congratulate all selected authors and co-authors of this book. It is for sure this book is a timely publication – that anyone can benefit from – featuring embedded theoretical approaches, practical experiences, and an expanded production possibility frontier for 'Global Food Security through Agricultural Transformation.' Sharing knowledge and skills does not have any physical boundary to accomplish our shared goal of 'food security' – a universal human right. This book certainly creates a ripple impact globally on collective responsibility to increase access to enough and safe food for healthy living. Any creative thoughts and suggestions in this regard may help NAPA while planning similar endeavors in the future. On behalf of NAPA, I appeal to each one of us to put agricultural transformation on priority agenda to reducing hunger worldwide.

Together, we can make a difference.

Lila B. Karki, Ph.D.
President, NAPA
February 11, 2020

Association of Nepalese Agricultural Professionals of Americas (NAPA)

The Association of Nepalese Agricultural Professionals of Americas (NAPA) was officially registered in Louisiana, USA, on January 6, 2016. NAPA is a non-profit, non-governmental, non-religious, and non-political professional organization dedicated to serving humankind through educational, scientific, and developmental initiatives. The first elected Executive Committee (EC) to kick off this professional society was commissioned at the historic general meeting held in Dallas, Texas, on May 27, 2016. Within its four years of establishment, NAPA has now fully grown as a professional society initiated by Nepali professionals in North America and around the globe; however, any eligible professionals across the globe may join NAPA. The collective effort, self-sacrificing commitment, and relentless hard work rendered by hundreds of dedicated members and volunteers have been the primary attributes for its growth, development, and sustainability. The IRS granted [501 (c) 3] Federal Income Tax Exemption Status and Public Charity Status 170 (b) (1) (A) (vi) in January 2016. As of April 2020, 376 professionals have joined NAPA; membership has expanded to 41 States in the USA; and the global membership has grown to Australia, Canada, Mexico, and Nepal. As per NAPA's mission, national and international collaborations and networking have been established with several institutions/organizations.

The first biennial scientific conference organized in Oklahoma City, Oklahoma, USA, during May 26-27, 2018, has set the stage for NAPA's professional stature and global visibility. The second biennial scientific conference scheduled in Atlanta, Georgia, USA, is going to strengthen its strategic vision. As a rapidly growing professional society, NAPA has firm willpower to contribute to academia through scientific publications. Consequently, a book entitled **“Principles and Practices of Food Security: Sustainable, Sufficient, and Safe Food for Healthy Living in Nepal”** is now in your hands. This book serves NAPA's perspective as a shared responsibility to the overarching vision **‘Global Food Security through Agricultural Transformation.’** Likewise, NAPA has established the publication of its flagship journal entitled *Global Journal of Agricultural and Allied Sciences*. In the array of publications, **Agri-Connection**, an online quarterly newsletter, has been showcasing the professional development and scientific contribution of its member community regularly since its inception. Correspondingly, **Research/Policy Brief** (an online publication), is another academic publication serving our community and beyond.

NAPA has its own donor-based **collaborative mini-research** projects to strengthen the research capacity of young and emerging professionals in agriculture and allied sciences. Of the showcase, **Webinar, Distance Education, Brain Gain, and Supervisory Services** are some of the capacity-building initiatives launched thus far. Similarly, NAPA has established **Scholarships for Academic Excellence** awarded to students in various agricultural and allied disciplines.

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INTRODUCTION: PRINCIPLES AND PRACTICES OF FOOD SECURITY IN NEPAL

Drona P. Rasali, Prem B. Bhandari, Uma Karki, Megha N. Parajulee,
Ram Acharya, Raju Adhikari

1. BACKGROUND

Food is a universal prerequisite for sustaining all life forms, and especially is an essential determinant of healthy living for mankind. If the food is not safe to eat, it can create a grave danger to human life. In Nepal, agriculture has been the mainstay of the economy as well as the main source of livelihoods for most people to date. Yet, it would be prudent to point out right at the outset that the country has been burdened with increasing dependence on the importation of food and agriculture inputs in recent times. Despite greater emphasis on agriculture development in the periodic national plans for nearly half a century now, the capacity to achieve appropriate agricultural education, the innovation of technology, multi-sectoral collaboration and investment required thereof have not been adequate to explore the vast potential of diverse agricultural resources to enable people to secure sustainably sufficient, safe and healthy food.

The sustainability, sufficiency, safety and healthy foods, affordability and rights to access them are essential aspects of the food security in the 21st century, constituting the key components of a complex food system of Nepal, while the country's food supply chain continues to face challenges due to diversity in geographic, agro-climatic and socio-economic conditions across the country. Moreover, most of the people who live in rural areas mostly under a subsistence economy, are facing serious challenges in sustaining their livelihoods ensuring food security in an increasingly globalizing world economy. Nepal's geo-politics and landlockedness, residual traditional feudalism, poor labor management systems, occasional natural calamities such as the devastating earthquake struck in 2015 and protracted armed conflict (Bk, 2018) with serious consequences in agricultural productivity and production (FAO, 2007) and also regional variations resulting in rural-urban differences (Bhandari, 2018) have been major factors in chronic and transient food insecurity and food deficit situations occurring in various parts of the country. Hence, the current state of the food system in terms of nourishing the people in the country is less than optimal. In order to nourish the country's ever-growing population, a system of sustainable food production, processing, preservation, distribution, marketing, and accessing food in sufficient, safe, healthy and equitable manner is essential.

The United Nations' Food and Agriculture Organization (FAO) defines food security as a situation that *"exists when all people, at all times, have physical, social and economic access to sufficient, safe and nutritious food that meets their dietary needs and food preferences for an active and healthy life"* (CFS, 2013). This definition is grounded on its framework with the four pillars of food security, namely: availability, access, utilization and stability. The framework assumes the nutritional dimension as integral to the concept of food security, while food choices are inherent to it, though it is not well emphasized. This book aims at utilizing the FAO definition to its full meaning, by broadening its scope based on its food security framework, with additional dimensions of food production including soil health to crop improvement, agronomic cereal crop and livestock production, food safety considerations and climate change impacts for sustainable food production. It also aims at going beyond food production and utilization to the human component of making choices for healthy eating for an active and healthy life.

The book incorporates relevant principles and practices of various aspects of food security that would support the achievement of three priority-oriented goals described in an agreement signed recently between the Government of Nepal and the UN's Food and Agriculture Organization (FAO) for cooperation (FAO, 2019). These goals are: 1) to enhance sustainable agricultural production and productivity, marketing and consumption for the eradication of hunger and malnutrition, 2) to enhance natural resource management and agricultural production systems, making them resilient to climate change and disasters, and 3) to relate to inclusive and gender responsive livelihoods enhancement and poverty reduction (FAO, 2019), which will in turn support the achievement of the UN Sustainable Development Goal of Zero Hunger by 2030.

2. WHY IS THIS BOOK NECESSARY?

Considering the whole gamut of the complexities of agriculture-dependent food security prevailing in Nepal, scientists and academics mostly living out of the country have realized that there exists a gap in knowledge translation of vast scientific data and information, integrating production systems, production and post-harvest processing and marketing and utilization of food for a broader food security than just providing food for subsistence. In order to address this gap, the Association of Nepalese Agricultural Professionals in Americas (NAPA) has undertaken an initiative to publish a book that integrates these components of food security so that it would influence healthy public policies, programs, services and innovative technologies through the dissemination of such knowledge. The book is an attempt to cover various aspects of the principles and practices of food security, and hence it is subtitled accordingly: “Sustainable, Sufficient, and Safe Food for Healthy Living in Nepal”.

The originally envisioned target readership of the book includes: 1) Planners, policymakers and decision makers at various levels of the governments under the federal structure of Nepal; 2) Non-governmental organizations program officers; 3) Agricultural officers and food economists; 4) Faculty and graduate-level students of food security and food systems; 5) Civic leaders and intellectuals; 6) Food industries, producers, retailers and suppliers; and 7) Food hospitality stakeholders, who would benefit from the knowledge and skills gained from the book for improving the Nepal’s food security situation.

3. WHAT DOES THE BOOK BRING TO ITS READERS?

The book aims to compile and consolidate knowledge from wide-ranging information sources of diverse fields closely related to food security in terms of securing sustainable production and access to food, and sufficiently available and safely prepared food for the healthy living of the people. The book comprises 18 chapters including the introduction. Each chapter is written by a team of internationally engaged experts in the respective fields. Most of these experts do not only have the knowledge of the subject matter, but also have the firsthand experience of the prevailing complex food security situation of Nepal. Apart from this introduction, the book is divided into four groups of chapters. The *first group* includes chapters that deal with the general issues, socio-economic politics and policies of food security in Nepal. The *second group* of chapters deals with agricultural production and improved technologies of food security. The *third group* deals with the specific emerging topical issues, namely, food safety regulations, healthy eating approaches for adoption and climate change impacts that are considered increasingly important for the food security situation in Nepal. The *fourth group* consists of two chapters presenting promising innovative specialty technologies, one related to increasing food production through conservation of moisture using degradable plastic mulch and another related to food safety measures using non-destructive technology.

3.1 General and Socio-economic Issues of Food Security

Chapter 2, “Food Security and Sustainable Livelihood Framework” authored by P. B. Bhandari, L. B. Karki and D. P. Rasali, introduces the issue of food security as a complex concept which is multidimensional in nature, laying a sustainable livelihood framework with an integrated approach to studying various livelihood outcomes in the context of Nepal. The chapter also examines socio-economic, cultural and structural factors that determine food security at the household level using the Sustainable Livelihood (SL) framework which has been widely used to examine the factors influencing food security in developing countries. The chapter concludes by asserting that food security is primarily a geographically driven issue in the country, which varies by north-south as well as east-west geographic regions. In addition, at the household level, food security is greatly influenced by the access to various livelihood capitals.

Chapter 3 by Kaphle et al. relates to the food security status and challenges in Nepal by focusing on policy options available for improvement. The chapter opens with a review of the general food security situation in the country which was once a food exporting country and has now become a net food importer with 23 districts with net food deficits. Despite 29 percent of the GDP contributed from the agriculture sector and having a potential for basic food sufficiency, the country is burdened with widespread disparities across

geographic regions, locations, socio-economic hierarchies and intra-household gender differences. The authors discuss four pillars of food security- food availability, access, utilization and stability which need to be considered for policy changes for food production, timely supply, and household consumption, with embedded corrective reliefs such as food subsidy and supply for hunger-stricken areas, and technological interventions through chemical fertilizers and improved seeds for intensifying production in the fertile plain areas. They argue that food security is a heavily underfunded sector, while the rural traditional practices of securing food such as the Dharam Bhakari (a traditional grain saving scheme) have been abandoned due to urbanization with the food sector being increasingly driven by the market forces. The chapter mentions the provisions in the new Constitution of Nepal that offer the best opportunity for mobilizing the three tiers of governments with a constitutional provision to attaining the food security goal that guarantees food as a fundamental right of the citizens.

Chapter 4 by Sharma et al. posits that Nepal is currently at the crossroads between its responsibility to feed people and fulfill their multifaceted expectations. The authors argue that overemphasis on green revolution-based production systems has displaced indigenous knowledge-based technology and that has resulted in a decline in soil productivity, human health, biodiversity, and the environment. The Agricultural Development Strategy (ADS), the country's long-term plan currently under its implementation phase that was expected to address issues of poverty, food insecurity and agricultural sustainability targeting to meet the United Nation's Sustainable Development Goals (SDGs) has hidden shortcomings that require remedying. The chapter recommends some of the strategies such as integrated agro-forest-livestock based farming; local cooperatives; organic/ecological farming promoting local food and nutrition; climate-smart agriculture; urban and peri-urban farming; innovations like bioponics, tunnel, and roof-top farming as some of the strategies for the way forward.

Joshi and Khanal in **Chapter 5** link the local food security challenges faced by developing countries such as Nepal with a global context in which these countries are trying to ensure food security, as the world has embraced neoliberal economic policies so as to promote the free flow of resources and capital. This chapter critically investigates the dimension of the political economy of food security of Nepal. The authors find that dependency on free trade and the unprecedented rise of multinational companies are affecting the livelihood of small farmers in the global context. Investigating the historical context of the food security situation in Nepal – comparing the situation between pre-liberal and present era, with special focus on the far western region of Nepal, the authors argue that after excessively embracing liberalization policies, food sovereignty and sufficiency aspects have gone downhill. This chapter also highlights the likely influences of out-migration and remittances in solving challenges of food security and poverty in the country. The chapter forecasts that in the long run, macro-economic conditions such as trade balances and the inflation rates of the country would suffer, suggesting that policies should focus on the increasing growth of food production within the country, the reduction in food prices in local markets and increasing farm incomes so as to improve the poor people's access to food.

Chapter 6, “An Overview of Household Food Security”, by Mishra et al. presents a general overview of the various aspects of household food security as the foundation of the food security issues, differentiating it from individual, regional and national levels. The chapter focuses on the socio-economic aspects of household food security in the context of Nepal. The chapter also briefly touches on emerging issues such as climate change, socio-economic policies, health and hygiene, gender, caste and ethnic factors that have had a bearing on household food security issues in the country.

In **Chapter 7**, “The Dynamics of the Food Basket Composition among the Chepangs”, the authors L. Piya and N. Joshi introduce the socio-economic issues of food affordability, presenting a case study of one of the highly vulnerable marginalized indigenous communities - the Chepangs. This chapter empirically examines the dynamics of the food basket composition among the Chepangs showing declining consumption of millet from its own production and wild tubers. The authors argue from a political economy perspective that a shift towards increasing households' purchase of rice, lentil, cooking oil, chicken, eggs, and sugar

from the market is occurring as a result of participation in a wage economy, adoption of cash crops, external markets, restrictive forestry policies, and the introduction of new crops and food choices.

Lastly in the group, **Chapter 8**, “Capacity Building of Food Value Chain Players: Why and How?”, authored by R. Ghimire and K. Nakasone deals with the issues of food sustainability, building from the knowledge management and asset-based community development concepts, explaining why the capacity building of various food value chain actors is critical to attaining food sustainability. The chapter introduces the concept of the food sustainability, lists the food value chain actors, food security related laws and provisions, roles, and the capacity of the food value chain actors, and the way forward to improving the actors’ capacity to attaining food sustainability. The chapter also focuses on the need to motivate youths to pursue farming and educate farmers to continue to grow what is sustainable in their farming systems.

3.2 Sustainable Agricultural Production for Food Security

This group includes five chapters. Two chapters deal with the improvement in agronomic principles and practices of cereal crop production and crop intensification especially of rice production; one chapter that focuses on soil health for crop improvement; another chapter focuses on improvement of fruits and vegetables production and one chapter on livestock production improvements. These chapters discuss the ways and means of sustainable production for food sufficiency through production and distribution of cereals, fruits and vegetables, and livestock products.

In **Chapter 9**, “Cereal Crop Improvement for Food Sufficiency”, Tiwari et al. underscore the importance of three major cereal crops, Rice (*Oryza sativa L.*), maize (*Zea mays L.*), and wheat (*Triticum aestivum L.*) accounting for over 95 percent of all cereal food production. They explain that increased productivity of these key cereal crops is crucial for the food sufficiency system in Nepal. This chapter reviews the current research on varietal improvement of major cereal crops and discusses future strategies for increasing food production in Nepal and emphasizes on future research on utilization of advanced genomics to expedite cultivar improvement for higher yields, pest resistance, and seeds production.

Chapter 10, “Agro-ecological Intensification for Sustainable Food Production: Opportunities with the System of Rice Intensification” authored by Khadka et al. introduces the principles and techniques of the system of rice intensification (SRI) for improving rice production. Through the enhancement of the growing environment and management of the soils, plants, water, and nutrients, with positive effects on roots growth and beneficial organisms in the soils, the SRI offers solutions for dealing with challenges in rice production such as low productivity, low soil fertility, land degradation, and climate-change impacts showing enhancement of paddy yields up to 50-100 percent. The chapter explains that the system requires lower seed and water requirements compared to conventional practices, resulting in the higher grain yields under organic management, and positive response of plants to the inoculation of plants and soils with beneficial microbes. This intensification practice can also be applied to other crops by adopting the SRI principles and techniques.

Considering that the soil provides the foundation of land-based agriculture for food production sustainability, R. Ghimire, U. Sainju and R. Acharya in **Chapter 11**, “Soil Health for Food Security and Agroecosystem Resilience” focus on soil health assessed in terms of agricultural ecosystem’s resilience. The chapter explains how in the face of changing climatic events, such as global warming-related increased air temperature, the vulnerability of crops to biotic and abiotic stresses can be increased, negatively affecting agroecosystem resiliency and food security. The authors describe how an increased net farm profitability and environmental sustainability can be realized through improved soil and crop management practices that enhance soil health and quality due to increased soil organic matter (SOM), improved nutrients and water use efficiency and reduced nitrogen (N) leaching and greenhouse gas emissions while maintaining or enhancing crop production. They propose for the implementation of some of the practices such as reduced tillage, crop residue returned to the soil, diversified crop rotations, reduced N fertilization rates, cover cropping, manure and compost applications, and integrated crop-livestock systems. These practices could benefit the rain-fed agricultural production in South Asia including Nepal through improvements in soil

health and crop production. This chapter focuses on alternative soil and crop management strategies that enhance soil health and crop production in the small land-holder farming conditions in Nepal and highlights the need for programs and policies to support producers for increasing SOM sequestration through carbon-credit markets and reducing chemical use while maintaining crop yields and qualities.

Chapter 12, “Current Status of Fruits and Vegetables and their Improvements” by Panthee et al. underscores the importance of fruits and vegetables for improving the nutritional status of people leading to improvement in overall human health and contributing to the national economy as well. The authors present the state of the research in various horticultural crops including apples, citrus, mangoes, and vegetables such as potatoes, tomatoes, leafy vegetables, cole crop and indigenous crops. The economic contribution of fruits and vegetables is discussed as well. Information from Nepal and the international level is presented for comparative analysis purposes. Based on the critical analysis, the authors conclude that the current status of the contribution of plant breeding towards the improvement of the nutrient content of fruits and vegetables crop improvement gap needs to be considered in the future for the overall health benefit of society. This analysis may be helpful for plant breeders, public health-related researchers, and policymakers.

Chapter 13, “Principles, Practices and Future Directions of Sustainable Livestock Production” Karki et al. outlines the various important aspects of livestock production, focusing on ruminant animal production in Nepal. The chapter discusses essential issues of sustainable livestock production systems, highlighting the historical perspectives of livestock development and current endeavors being made as well as opportunities for improvement, especially focusing on ruminants. The chapter is divided into four different sections: sustainable livestock production systems, the socio-economic importance of livestock, feeds and forages, and sustainable dairy production.

3.3 Food Safety Regulations, Healthy Eating and Climate Change Impacts

This group of chapters presents three different emerging topical issues of food safety regulations, healthy eating choices and climate change impacts on food security that are emerging as important aspects of food security in Nepal.

Chapter 14, “Food Safety and Quality Regulations: Status, Issues and Way Forward” authored by Bajagai et al. presents a legislative framework for food safety regulation as an important aspect of improving food security in Nepal, discussing an overview of major legislations, regulations, government plans and policies, institutional infrastructure and capacity, the national food safety control systems in place, and food standards. The chapter also compares the food safety regulatory system in the developed world, giving an example of Australia and New Zealand. As a member nation of different international organizations, Nepal has many food safety-related obligations to comply with the rules and regulations of those organizations. Food safety-related issues started to become a matter of increased concern and one of the priority areas of the government after the country became a member of the World Trade Organization (WTO) in 2004. In general, there is strong legislative and institutional infrastructure in place to manage the safety of food. Currently, food safety-related problems in Nepal are mainly attributable to the weak implementation of legislation rather than the absence of such legislation and guidelines. However, the prevailing laws, standards, and guidelines should be updated and harmonized to international standards to address the emerging threats and issues. In the context of the recent restructuring of the government system to federalism, there needs to be more clarity about the roles and responsibilities of the central, provincial and local governments, transitioning from the currently prevailing status to new federal structure of Nepal with the roles and responsibilities distributed across the central, provincial and local governments. The prevailing legislation should be updated where necessary in order to authorize the provincial and local governments to control the safety of food within their respective jurisdictions with the allocation of adequate resources for skilled human resources and infrastructure development. Coordination of food scientists and public health experts are crucial in this regard.

Chapter 15, “Securing Food Choices for Healthy Eating” authored by D. P. Rasali and S. C. Johnson focuses on the concept of “healthy eating” as an integral part of food security in Nepal, making a choice of a “pattern of eating” that supports a healthy and a balanced diet in the way healthy food is accessed, what constitutes healthy eating habits and how eating behaviors can be modified. The chapter contends that securing adequate food to ensure optimal eating is a key protective factor for growth and maintenance of a healthy life through preventing malnutrition including stunting, wasting, underweight and excess weight. Furthermore, increasing socio-economic and geographic accessibility to nutritious food, affordable healthy food choices, use of traditional healthy foods and supplementing with wild edible plants are some of the prevention strategies aimed at encouraging healthy eating to reduce the burden of non-communicable diseases, which is ever increasing. The authors posit that making healthy choices and meeting nutritional needs based on a nationally recommended daily intake of nutrients are fundamental to reducing the burden of these diseases through behavioral changes and practices for health and well-being. The chapter also emphasizes that knowledge and skills for growing, planning, purchasing and preparing healthy food is crucial in making appropriate changes to healthy eating lifestyles, especially avoiding high sodium and sugar intake.

Chapter 16, “Assessing Agriculture System for Food Security amidst Changing Climate” authored by Paudel et al. underscores the fact that climate change affects agriculture and food production in a complex way, impacting food and animal production directly through changes in agro-ecological environments and indirectly by influencing socio-economic conditions, thus impacting the demand-supply continuum for agricultural products. In order to address these changes in numbers and intensity, the authors argue for a simultaneous yet multi-sectoral, and holistic approach along with the development of crop cultivars and livestock breeds adapted to the changing climate and the formulation of management strategies for improving the resilience of farmers in securing food security. The chapter also points out that a comprehensive agriculture research system is instrumental in order to constantly monitor the challenges in food supply and to assemble the most sustainable climate change plan of action.

3.4 Two Technologies of Specialty

This group of chapters introduces two innovative technologies that have future promise for food security in Nepal. These specialty technologies, though different in scope and purpose, have the promise of addressing two separate problems of food security - one related to agronomic practices and another related to food processing. One chapter deals with improving soil conditions by improving its moisture using innovative mulch made from degradable plastic material, while the other chapter deals with non-destructive technology to assess the quality of food for keeping the food safe.

Chapter 17, “The Polymer (Plastic) Technology for Food Security” authored by R. Adhikari and M. O’Shea, discusses the history of polymer technology, its prospects and application for crop production, and the impact on global food security, and describes the principles and practices of use of the polymeric (plastic) mulch technology for increased global crop productivity by controlling soil’s moisture, temperatures, micro-environment and weeds growth. The use of plastic mulch and seed treatment technologies being an integral part of modern agriculture farming will play a major role to increase crop productivity and to guarantee food security to feed the ever-increasing human population. The authors argue that Nepal’s current agricultural practices for increased food production based on conventional irrigation systems are not sustainable in the future and is detrimental to the soil and environment due to excessive use of nutrients and chemicals in such a system. As Nepal aspires to modernize its agriculture industry, it can adopt appropriate advanced agricultural technologies such as degradable plastic mulch to guarantee moisture conservation in the unirrigated areas for sustainably increased food production and thus provide long term food security.

Chapter 18, “Non-destructive Assessment of Food for Safety and Quality” authored by B. P. Khatiwada and U. K Acharya introduces optical methods of assessment of food safety and quality as commonly used in developed countries, allowing online and real-time assessment of food quality and safety. These non-destructive methods of quality assessment are in practice along the supply chain in the food system in

developed countries. This chapter provides an overview of non-destructive techniques of assessing food safety and quality with a focus on basic and recent advances on the use of the near-infrared spectroscopy (NIRS) method to assess food safety (such as adulteration, toxicity, frauds, authenticity, pesticides residues) and quality (such as carbohydrates, proteins, fats, dry matter, soluble solids, internal defects). This chapter outlines a pathway for advancing food safety and quality assessment and its regulations in the food system in Nepal. Examples include the meat and dairy industry, the cereals and grain industry and the fruits and vegetables industry. The NIRS, a proven and cost-effective tool for long term quality control and food safety and quality surveillance is relevant to high-end food safety processing in Nepal.

Overall, this book attempts to cover various aspects of food security including food production, distribution, access, utilization, stability, quality, and nutrition aspects, while the issues of socio-economics, principles and practices of sustainable production of sufficient food of plant and animal origins including technologies of production, food safety and healthy eating choices are addressed for improvement. The current state of food security in the country is less than optimal, while the food insecurity situation is worsening due to several factors. Some of these factors are: 1) the rudimentary traditional farming system not revitalized adequately in the face of the current need for feeding the ever growing population, 2) huge exodus of youth workforce to foreign countries for employment leaving behind barren cultivable land in the rural areas, 3) skyrocketing cost of family's food basket, 4) meager opportunities for both farm and non-farm employment, 4) rampant socio-economic disparities across the country and unequal access to various livelihood assets thereof, all of which make healthy food choices unaffordable for families. There is an acute need to reverse the situation to relieve the people, especially the vulnerable ones, from the suffering of hunger and food insecurity towards a future state in which all people can afford to access enough, safe and nutritious food, in order to be able to make their healthy food choices sustainable. Towards this end, all chapters conclude with a set of policy recommendations for improving sustainable and sufficient agricultural production through the development of appropriate technologies, infrastructure, investment of capitals, appropriate regulatory measures, and conducive policy and operational environments, in the context of Nepal. Lastly, this book is released in a challenging time in the midst of a global crisis of Covid-19 pandemic. While the issue of food security is universally recognized as a core public health problem, it has become even more important to emphasize on food security, which is hard hit by the pandemic crisis, especially among the vulnerable and marginalized segments of the population in the country.

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This well-researched and a science-based book cannot be timelier than now when the world is grappling with issues associated with food security. The book is highly comprehensive as it covers issues and remedies concerning food security at the farm to the policy levels. Although aimed at streamlining food security in Nepal, the principles and practices discussed in the book have a global application. This book is a must for students, researchers, and policymakers!

~Srinivasa Rao Mentreddy, Ph.D.

Professor

Alabama A&M University, Alabama, USA

Well-documented and praiseworthy work. The success of such an initiative would certainly reflect the quality and standard maintenance of the plant- and animal-derived food products. Indigenous technology and food habits are transformed with threatened public health. Multidisciplinary approaches are key to the sustainability of food safety and dissemination of innovative technologies and resources to researchers, policy makers, academicians and entrepreneurs are highly acknowledged.

~Ishwari Pd. Dhakal, Ph.D.

Professor and Former Vice Chancellor

Agriculture and Forestry University (AFU), Chitwan, Nepal

An informative book for those interested in the Nepalese agricultural sector in general and food security in particular. This book includes a wide range of chapters on and around food security such as socio-economic issues, production sustainability, policies and regulations, and technological aspects. Contributed by well-experienced authors, it could serve as an important resource for policy makers, researchers, academicians and students. In addition, this book makes a further contribution to the existing knowledge and practices on food security.

~Ganesh Raj Joshi, Ph.D.

Visiting Professor (Environmental Science), Tribhuvan University, Nepal

Former Secretary, Ministry of Agricultural Development; Forests and Environment
Government of Nepal

Safe, quality and healthy food is pre-condition for food security, healthy population and sustainable development. I hope that this book will be an eye-opener for policy makers, decision makers, researchers and intellectuals in Nepal to make a real way forward towards achieving sustainable development goals.

~Dr. Gyanendra Gongal

Regional Advisor (Food Safety), Healthier Populations and NCD
WHO Regional Office for South East Asia, New Delhi, India



**ASSOCIATION OF NEPALESE AGRICULTURAL
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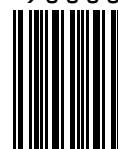
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