



Food and Agriculture
Organization of the
United Nations



MOUNTAIN AGRICULTURE

Opportunities for harnessing
Zero Hunger in Asia



Working for #ZeroHunger

MOUNTAIN AGRICULTURE

Opportunities for harnessing Zero Hunger in Asia

Editors

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Contents

	Boxes, figures and tables	iv
	Foreword	ix
	Note from the editors	xi
	Acknowledgements	xv
	About the authors/reviewers	xvii
	Acronyms and abbreviations	xix
	Executive summary	xxiii
PART I	SETTING THE SCENE	1
	Chapter 1 Introduction, mountain agriculture: opportunities for harnessing Zero Hunger in Asia	3
PART II	ENABLING ENVIRONMENT REQUIRED TO PROMOTE SUSTAINABLE MOUNTAIN AGRICULTURE DEVELOPMENT	23
	Chapter 2 The status, opportunities and challenges of mountain agriculture development to improve livelihoods and ensure food security and Zero Hunger	25
	Chapter 3 The potentials of Future Smart Food for mountain agriculture achieving Zero Hunger: nutrition, climate-resilient, economic and social benefits	45
	Chapter 4 Integrated farming systems development for mountain agriculture in Asia	57
	Chapter 5 Sustainable mountain agriculture through integrated and science-based watershed management: A case study	71
	Chapter 6 Integrated value-chain development of mountain products for poverty reduction and Zero Hunger	87
	Chapter 7 Integrated mountain agriculture development model: GIAHS	101
	Chapter 8 Strengthening the governance of mountain agriculture, food security and nutrition: An analysis of survey on mountain agriculture in Asia	113
PART III	COUNTRY STUDIES ON MOUNTAIN AGRICULTURE DEVELOPMENT	129
	Chapter 9 Bangladesh	131
	Chapter 10 Bhutan	159
	Chapter 11 India	173
	Chapter 12 Lao PDR	197
	Chapter 13 Myanmar	215
	Chapter 14 Nepal	231
	Chapter 15 Pakistan	245
	Chapter 16 Viet Nam	259
PART IV	COUNTRY STUDIES AND RECOMMENDATIONS	271
	Chapter 17 Conclusions, recommendations and the way forward for the sustainable development of mountain agriculture to enhance food security and nutrition	273

Boxes, figures and tables

BOXES

Box 4.1	Integrated farming systems for enhancing productivity and profitability under hill and mountain agro-ecosystems: a case study on the under-forestry economy (UFE) in China	64
Box 5.1	The Lucheba watershed at glance: 2012	77
Box 5.2	The improving prosperity and livelihood of Mr Yixianyou in the Lucheba in China through integrated watershed development	78
Box 6.1	Case study on the e-commerce development of agricultural products in China	90

FIGURES

Figure ES.1	The development process of the Mountain Consultation	xxiv
Figure ES.2	Development stages of food systems for Future Smart Food	xxvi
Figure ES.3	Policy framework for sustainable mountain agriculture development	xxx
Figure ES.4	The coverage of Asian countries in the country studies on Mountain Agriculture Development	xxxii
Figure ES.5	An integrated approach for the sustainable development of mountain agriculture	xl
Figure 1.1	Development process of the Consultation on mountain agriculture	13
Figure 1.2	A snapshot of the main issues of the three-day Mountain Consultation, 30 October–1 November 2018, Beijing	15
Figure 2.1	Mountains of the world	26
Figure 2.2	The different zones of a typical river basin and cryosphere model representation showing the different resources and services provided by mountains	26
Figure 2.3	Mountains are an important source of fresh water	27
Figure 2.4	The elevation and altitude gradient of mountains provide various sources of renewable energy including hydropower, solar energy and wind power	27
Figure 2.5	The drivers and impacts of the Water–Energy–Food Nexus in which mountains play an important role	28
Figure 2.6	Terrace design showing the relatively wide rice terraces in the Indonesia and narrow terraces (1 to 2 metres) in the steep mountains of Yemen	29
Figure 2.7	The cycle of poverty – natural resource degradation – poverty in mountain areas	29
Figure 2.8	Major agro-ecologies in the Tibetan Steppe	32
Figure 2.9	Major livestock species in the Tibetan Steppe: yak, sheep and goats	32
Figure 2.10	The various factors involved in the integrated crop–livestock–rangeland production system role	33
Figure 2.11	Successful technologies in the agro-pastoral livestock production system	33
Figure 2.12	Rainfed rice production in the highlands of Nepal and rainfed wheat in the highlands of Ethiopia	34
Figure 2.13	Ridges of irrigated high-value saffron in the highlands of Afghanistan (left photo), saffron flowers (middle), and Afghani women collecting saffron filaments as a high-value spice for the export market (right)	35
Figure 2.14	Plastic greenhouses for the production of high-value off-season vegetables on the narrow terraces of the steep mountains in Yemen	35
Figure 2.15	Added-value mohair fibre production by Tajik women from indigenous goat breeds in the mountain areas in Tajikistan	36
Figure 2.16	Minister of Agriculture of Afghanistan visiting the plastic greenhouses where fresh mint is grown in Afghanistan (left photo); women distilling fresh mint to produce both water mint and oil mint (middle); and vendors of water mint and oil mint in Kabul, Afghanistan (right)	37
Figure 2.17	Mountain women collecting water (left) and straw for fuel (middle), and harvesting vegetables in plastic green houses (right)	37
Figure 2.18	The Hindu Kush Himalayan (HKH) Region (dark blue) showing the basin of the major rivers that originate from that region	40

Figure 2.19	ICIMOD's diagram for "resilient mountain villages" to prepare for climate, socio-economic and future resilience	40
Figure 2.20	An integrated approach for the sustainable development of mountain agriculture	42
Figure 3.1	Development stages of food systems for Future Smart Food	52
Figure 5.1	Meta-analysis of watershed programmes in India based on economic parameters	73
Figure 5.2a	Water balance in Tad Fa watershed in Thailand: data for the wet year of 2000 (left); data for the dry year of 2001 (right)	74
Figure 5.2b	Water balance in the Xiaoxincun (left); and Lucheba (right) watersheds in China	74
Figure 5.3	Various interventions implemented in the watershed	75
Figure 5.4	Community and farming nursery of sweet potatoes	76
Figure 6.1	Export value of selected high value products in Hindu Kush Himalaya (HKH)	88
Figure 6.2	Model for integrated value chain development of large cardamom	91
Figure 6.3	In phase one (2015-2017) 16 products from seven countries were granted the Mountain Partnership Products label	95
Figure 6.4	Development of price, production, number of farmers and women of Jumla's mixed beans, Nepal since joining the Mountain Partnership Products initiative and receiving the label in 2016	96
Figure 6.5	In 2018 400 Female producers are cultivating Jumla's mixed beans in Nepal and could benefit from a price increase of 20 percent as a result of the Mountain Partnership Product label	96
Figure 7.1	Honghe Hani Rice Terraces System in Yunnan Province	105
Figure 7.2	Guizhou, home to the Dong's rice-fish-duck system	105
Figure 7.3	Shaoxing Kuaijishan ancient Chinese Torreya in Zhejiang Province	106
Figure 7.4	The Fengqiao Torreya nuts	107
Figure 7.5	Multi-functional agriculture and related industries	108
Figure 7.6	The Dong chorus singers	108
Figure 8.1	Development stages of food systems and value chain for mountain speciality products	117
Figure 8.2	Policy framework for sustainable mountain agriculture development	120
Figure 9.1	Map of Bangladesh	131
Figure 9.2	Climate zones of Bangladesh	132
Figure 9.3	Agro-ecological conditions of Bangladesh	132
Figure 9.4	Location of the CHT in Bangladesh	134
Figure 9.5	Landforms and elevation of the CHT in Bangladesh	135
Figure 9.6	Poverty status of nationals vs the CHT in Bangladesh	136
Figure 11.1	Agricultural activity in different states in the Indian Himalayas (km ²)	176
Figure 11.2	Average yields of food grain crops in the three states of the North-Western Hill Region of the Indian Himalayas	177
Figure 12.1	Agro-ecological zones of Lao PDR	198
Figure 12.2	Distribution of annual rainfall in Lao PDR	198
Figure 13.1	National GDP of Myanmar and proportion of GDP from the agricultural sector	216
Figure 14.1	Agro-ecological zones and farming systems in Nepal	236
Figure 15.1	Prevalence of undernourishment across regions in Pakistan	250
Figure 15.2	Regional distribution of households in terms of adequate calorie consumption in Pakistan	250
Figure 15.3	Regional distribution of households in terms of the prevalence of low dietary diversity in Pakistan	251
Figure 15.4	Regional distribution of households deriving more than 60 percent of their dietary energy from cereals dietary energy from cereals in Pakistan	251
Figure 15.5	Regional distribution of households that have experienced a natural disasters or adversity in the last three years in Pakistan	252
Figure 15.6	Regional distribution of households consuming less than the recommended level of vitamin A, iron and zinc in Pakistan	252

Figure 16.1	Multi-dimensional poverty rate in 2016 by region in Viet Nam	260
Figure 16.2	Household income structure by region in Viet Nam, 2015	261
Figure 16.3	Main farming systems by elevation in the Northern Midland and Mountainous region in Viet Nam	262
Figure 16.4	Percentage of communes within regions that have agricultural development support services in Viet Nam	264
Figure 17.1	The three major pillars for the development of sustainable mountain agriculture and their integration at farm and farmer levels to achieve synergy in productivity and production	277

TABLES

Table 1.1	Distribution of vulnerable rural mountain populations living in developing countries of the Asian region in 2012	4
Table 1.2	General agro-climatic features between mountain agriculture and plain agriculture	7
Table 1.3	Four main dimensions of food security	8
Table 1.4	Objectives and outputs of the Mountain Consultation, 30 October–1 November 2018, Beijing	14
Table 3.1	Future Smart Food examples	47
Table 3.2	Comparison of nutritional value between selected millets and staple crops	49
Table 5.1	Details of case watershed sites in China and Thailand	72
Table 5.2	The impact of improved watershed management in reducing runoff water	75
Table 5.3	Changes in area and yield of major crops before and after watershed management in the Lucheba watershed in China	76
Table 5.4	Changes in crop production system and field inputs and outputs in 2003 and 2012 in the Lucheba watershed in China	77
Table 5.5	Impact of watershed management interventions on forage production development in the Lucheba watershed in China	80
Table 5.6	Various inputs used in the production of different crops during 2012 in the Lucheba watershed in China	80
Table 5.7	Cost of inputs, yield levels and net returns in different crops produced during 2012 in the Lucheba watershed in China	81
Table 5.8	Benefit-cost ratio of the production of different crops in 2012 in the Lucheba watershed in China	81
Table 5.9	Marketing patterns in 2012 in the Lucheba watershed in China	82
Table 5.10	Employment and income from farm and non-farm activities before and after the watershed management project in the Lucheba watershed in China	82
Table 5.11	Gross income of farming households before and after the watershed management project in the Lucheba watershed in China	82
Table 6.1	Five key characteristics of resilient community	89
Table 7.1	Five main functions of agriculture in GIAHS sites	102
Table 7.2	Designated GIAHS in Mountainous Area	104
Table 9.1	Population of the CHT vs nationals	132
Table 9.2	Poverty headcount ratio	133
Table 9.3	Distribution of administrative units in the CHT in Bangladesh	134
Table 9.4	Demographic profile of the CHT in Bangladesh	135
Table 9.5	District wise land under different elevations in the CHT in Bangladesh	136
Table 9.6	Gradient of CHT hills in Bangladesh	136
Table 9.7	Land cover in the CHT in Bangladesh	137
Table 9.8	Classification of land by crops suitability in the CHT in Bangladesh	137
Table 9.9	Season wise average rainfall distribution in the CHT in Bangladesh	137
Table 9.10	Population figures for three districts of the CHT classified according to the four IPC chronic food insecurity levels in Bangladesh	138
Table 9.11	Overview of mountain agriculture and FSN in Bangladesh	139
Table 9.12	Description of agricultural lands in the CHT in Bangladesh	140
Table 9.13	Fruit production in the CHT in Bangladesh	141

Table 9.14	Livestock and poultry population in the CHT in Bangladesh	142
Table 9.15	Distribution of population by livelihood source in the CHT in Bangladesh	143
Table 9.16	List of Future Smart Food in the CHT in Bangladesh	150
Table 10.1	Agro-ecological zones and agriculture production in Bhutan	159
Table 10.2	Poverty outcomes during 2007, 2012 and 2017 in Bhutan	160
Table 10.3	Summary of the farming systems in different agro-ecological zones in Bhutan	162
Table 10.4	List of Future Smart Food in Bhutan	165
Table 11.1	The mountainous regions and climatic areas of the Indian Himalayas	175
Table 11.2	Demographics and agriculture indicators in the Indian Himalayas	177
Table 11.3	Predominant farming systems in different zones of the Indian Himalayas	178
Table 11.4	List of Future Smart Food in the mountain areas of India	181
Table 12.1	Agro-Ecological Zones (AEZ) in Lao PDR	199
Table 12.2	Five-year (2011–2015) socio-economic development performance in Lao PDR	200
Table 12.3	Poverty headcount rates by regions in Lao PDR	200
Table 12.4	Nutritional status of children under 5 years in Lao PDR	202
Table 12.5	Poverty headcount rate by altitude in Lao PDR	203
Table 13.1	Poverty in Myanmar	216
Table 13.2	Food poverty in Myanmar	217
Table 13.3	Calorie intake (adult equivalent per day) and food share of total household consumption in Myanmar	217
Table 13.4	Elevation range in the mountain region states of Myanmar	218
Table 13.5	Major economic activities and sources of livelihood by mountain region state	218
Table 13.6	Poverty rate in mountain regions compared with national poverty rate in Myanmar	218
Table 13.7	Land classification and distribution in mountain areas vs. country in Myanmar	218
Table 13.8	Population: Mountain areas vs. country in Myanmar (2014)	219
Table 13.9	GDP: Mountain agriculture vs. country in Myanmar	219
Table 13.10	Main mountain agricultural activities and products in Myanmar	219
Table 13.11	Income of Myanmar	219
Table 13.12	Slope, plot size, and planting dates for each plot of case study in Myanmar	227
Table 13.13	Soil loss and runoff from bare and cropped plots from adjacent sites with the features described in table 13.12	228
Table 14.1	Overview of mountain agriculture, and food security and nutrition in Nepal	234
Table 14.2	List of Future Smart Food in the mountain areas of Nepal	239
Table 14.3	Beneficiaries in the value chain of social inclusion in Nepal	241
Table 14.4	Sub-project agreements with districts in hill and mountain regions in Nepal	241
Table 16.1	Six ecological regions of Viet Nam	259
Table 16.2	Socio-economic status of Viet Nam	261
Table 16.3	Agro-climatic conditions in Viet Nam and the North	261
Table 16.4	Common crops of the Northern Midland and Mountainous region in Viet Nam	263
Table 16.5	List of Future Smart Food in the mountain areas of Viet Nam	266
Table 16.6	National programmes on hunger eradication, poverty reduction, and sustainable development in the Northern Midland and Mountainous region in Viet Nam	268



Foreword

Mountains are home to one tenth of the world's population, and cover one fifth of the world's land mass. To most of us, mountain regions offer landscapes of spectacular scenic beauty – but what we don't see are the lives and struggles of the people who live in the mountains, many of whom are poor and marginalized. Going by the global average, one in eight persons is food insecure, but in rural mountain areas this ratio is one out in two. This means that around 300 million mountain people are food insecure, with half of them suffering from chronic hunger. FAO has been providing global leadership on sustainable mountain development for decades, including overseeing the implementation of the mountain-related chapter of Agenda 21, the blueprint for sustainable development of the 1992 UN Earth Summit, and the International Year of Mountains in 2002. While mountain agriculture has made some headway, identifying innovative responsive solutions that target mountains directly in relation to Sustainable Development Goal 2 – Zero Hunger – remains a work-in-progress.

This publication – led by FAO's Regional Office for Asia and the Pacific and partners from national governments, national agriculture institutes, universities, international organizations and international research institutes – aims at raising awareness of the issues encountered by mountain farmers in Asia, and outline how mountain agriculture could better contribute to food security and better nutrition in Asia. The objectives of this publication are to (1) demonstrate constraints, gaps and opportunities in mountain agriculture to tap underutilized areas and resources for Zero Hunger and poverty reduction, (2) identify possible entry points and policy recommendations to develop sustainable mountain agriculture and strengthen food security and nutrition governance, and (3) promote knowledge sharing and exchange of good experience and practices related to mountain agriculture development for Zero Hunger.

Why does mountain agriculture deserve special attention in a Zero Hunger context? Firstly, because hunger remains common in many mountainous areas. While on a global scale, food insecurity has tended to go down, mountain dwellers have fared worse than people living in plains. Secondly, because mountains cover a large part of the world, especially in Asia: the continent hosts more than one-third of the world's mountains. Many Asian countries are dominated by mountains: for instance, nearly the entire land area in Bhutan is mountainous, and Lao PDR has 89 percent of its land area classified as mountainous or upland – farmers have no option but to derive their livelihoods from mountain agriculture. Thirdly, mountain agriculture can produce a large variety of nutritious foods not normally available from large-scale agriculture practised in the plains. Strengthening mountain agriculture must therefore be set as a priority for achieving Zero Hunger.

But how can mountain agriculture be effectively developed to achieve Zero Hunger? Mountain agriculture faces a number of constraints including inaccessibility, shorter and more pronounced agricultural seasons, ecological fragility, limited infrastructure, and distant markets. Yet, mountains contain more diversity than plain regions: their varied landscapes and the changes in altitude have created a multitude of agro-ecological zones. The genetic variety of agricultural crops and farm animals contained in these zones has the potential to provide diversified and nutritious food for all. The potential of mountain agriculture lies in mountain specialty products (e.g. Future Smart Foods: neglected and underutilized species that are nutritionally dense, climate resilient, economically viable, and locally available or adaptable), off-season products as well as agrotourism.

Conventional approaches in mountain agriculture have not been able to reduce hunger and malnutrition. The transition to food systems that are nutrition-sensitive, climate-smart and sustainable requires government leadership to reinforce intersectoral efforts and acknowledge the wealth and diversity of mountain agriculture. This publication provides a clear message to policymakers, researchers and practitioners: we must include mountain agriculture in our agendas when tackling hunger and malnutrition, poverty alleviation, conservation and sustainable use of biodiversity, and climate change adaptation. We have to work together in our commitment to include mountain agriculture and “leave no-one behind” on the road towards achieving the Zero Hunger goal.



José Graziano da Silva

Former Director-General

Food and Agriculture Organization of the United Nations

Note from the editors

Mountain food security and nutrition are core issues that can contribute positively to the achievement of the Sustainable Development Goals but paradoxically are often ignored in Zero Hunger and poverty reduction-related agenda. Under the overall leadership of José Graziano da Silva, the Former Director-General of FAO, to effectively address this issue and assist Member Countries in tackling food insecurity and malnutrition in mountain regions in the Asia and the Pacific, Kundhavi Kadiresan, Assistant Director-General and Regional Representative of FAO RAP, launched an initiative on mountain agriculture, building on strong foundations and long-standing FAO experience on Mountain Partnership, agricultural diversification, sustainable and integrated farming systems, and sustainable natural resources management and use. The sustainable mountain agriculture development initiative's priority setting and activities are currently carried out through the Regional Initiative on Zero Hunger (RI-ZH) of FAO RAP. The initiative on mountain agriculture for Zero Hunger received strategic guidance from Daniel Gustafson, Deputy Director-General (Programmes) of FAO, and has been endorsed by the Director-General of FAO.

The RI-ZH of FAO RAP was formulated to assist its Member Countries following the launch of the global Zero Hunger Challenge (ZHC) at the Rio+20 Conference in June 2012, and the Asia-Pacific regional ZHC in April 2013 organized by the United Nations and associated agencies, with participation by heads of governments, and other high-level and senior officials from across the region. Subsequently, the United Nations Regional Thematic Working Group on Poverty and Hunger, chaired by the FAO, along with UNESCAP and UNDP, prepared the "Regional Guiding Framework for Achieving Zero Hunger in Asia and the Pacific." This Framework calls for all stakeholders to support and carry the momentum forward with concrete action at the country level. Under this Framework, RI-ZH established three major programmatic work areas in consultation with governments:

- 1 Creating environments for food security and nutrition.
- 2 Data collection, analysis, and monitoring on food security and nutrition.
- 3 Strengthening sustainable agriculture and food systems.

The mountain agriculture initiative has been an integral component under RI-ZH since 2018. The initiative is implemented under the overall Strategic Programmes of the FAO to "contribute to the eradication of hunger, food insecurity and malnutrition," as well as to "support the rural poor in improving their income-generating capacities through better access to productive resources, markets, services, technologies and social protection" in collaboration with various other strategic programmes.

In the second half of 2018, under the leadership of Kundhavi Kadiresan, RI-ZH and its partners organized an International Workshop and Regional Expert Consultation on Strengthening Mountain Agriculture Development and Food Security and Nutrition Governance for Zero Hunger and Poverty Reduction in Beijing (hereafter "the Mountain Consultation"), which considered key issues in mountain areas in the context of sustainable agriculture development and food systems that drew regional attention, cooperation and policy solutions to enhance food security and nutrition governance in mountainous and hilly areas.

Prior to the Mountain Consultation, conceptualization and partnership building were consolidated based on strong country desires for knowledge sharing at the regional level on promoting sustainable mountain agriculture and enhancing food security and nutrition in mountain areas to address Zero Hunger and poverty reduction. The conceptualization was formulated through close technical consultation with Mahmoud El Solh and Kadambot H. M. Siddique. The Mountain Consultation was co-organized by the FAO and University of International Relations in China, in collaboration with The University of Western Australia, International Centre for Integrated Mountain Development (ICIMOD), Mountain Partnership, International Crops Research Institute for the Semi-Arid Tropics (ICRISAT), and Center for International Agriculture Research of Chinese Academy of Agriculture Sciences.

The Mountain Consultation received enormous support and dedication from national governments and national agriculture/mountain research organizations, who were engaged in activities before and during the Consultation to address the common challenges that Asian countries face in the sustainable development of mountain agriculture. For instance, high-level experts from the Nutrition Development Foundation and Royal Project Foundation from Thailand contributed technical presentations and successful country studies on nutrition governance, niche and development of local products for value addition, diversified livelihoods and agritourism in the mountains.

In addition, national mountain agriculture experts from national research institutes in nine Asian countries (Bhutan, Nepal, Myanmar, Cambodia, Vietnam, Lao PDR, India, Pakistan and Bangladesh) prepared preliminary Country Reports on Sustainable Mountain Agriculture Development for Achieving Zero Hunger and Poverty Reduction, in coordination with their government officials, based on FAO guidelines. The reports were circulated for international review before the Mountain Consultation. The national mountain agriculture experts presented at the Mountain Consultation to generate further discussion for the preparation of this publication. Moreover, a comprehensive set of Questionnaires on Mountain Agriculture in Asia were distributed to all participants at the Mountain Consultation for the purposes of data gathering and deliberative consultation.

The objectives and outputs of the Mountain Consultation, 30 October–1 November 2018, Beijing are presented below:

Objectives	Outputs
1 Identify constraints, gaps and opportunities on mountain agriculture development for poverty reduction and Zero Hunger	1 Key challenges and potential identified for agriculture and food systems in mountain areas (production, agro-processing, marketing and consumption)
2 Facilitate knowledge sharing, lessons learned and good practices on sustainable agriculture development and mountain food security and nutrition governance	2 Good experience, practices and solutions for enhancing sustainable mountain agriculture development (e.g. production, agroprocessing, marketing and consumption) and mountain food security and nutrition governance
3 Identify possible entry points and policy recommendations for promoting sustainable mountain agriculture development, and strengthen food security and nutrition governance	3 Recommendations and roadmaps for the way forward for mountain food security and nutrition governance developed

Comprising five sessions, the first day's programme was designed for international experts to share advanced experiences/programmes/lessons learned and success stories for sustainable mountain agriculture development from a global policy and technical perspective. International experts led state-of-art presentations on the following topics based on the framework of a sustainable food system: (1) Sustainable Mountain Agriculture Development and its Contribution to Food Security and Nutrition Governance; (2) Mainstreaming Neglected and Underutilized Species (NUS) for Mountain Agricultural Development: The Role of Future Smart Food (FSF); (3) Building Sustainable and Integrated Farming Systems for Mountain Agriculture; and (4) Promoting Integrated Value Chain and Market Access for Mountain Products.

On the second day, experts from nine Asian countries (Bangladesh, Bhutan, Cambodia,¹ Lao PDR, India, Myanmar, Nepal, Pakistan and Vietnam) that have implemented the RI-ZH shared their experience regarding the constraints, gaps and opportunities on sustainable mountain agriculture development for poverty reduction and Zero Hunger. The reports revealed that despite positive developments for reducing poverty nationwide, each country is suffering from similar problems such as the lack of interest of young people in agriculture, outmigration and the feminization of agriculture, degradation of natural resources as well as the serious implications of climate change on natural resource management and mountain agriculture.

On the final day, the experts and participants convened for three policy dialogue sessions to discuss gaps and challenges in mountain agriculture within national policies and strategies for mountain agriculture, food security and nutrition governance development. David Molden, Director General of ICIMOD, highlighted the need to stand up

¹ The country study from Cambodia is not included in this publication due to limited national data on mountain agriculture available. To access the presentation from Cambodia at the Mountain Consultation, please visit the website on Regional initiative of Zero Hunger at FAO RAP.

collectively for mountain agriculture issues and raise the voice of mountain people, as mountains are hotspots for Zero Hunger, climate change and migration. As an outcome of the workshop, Mahmoud El Solh presented “Recommendations for Policy Makers for Sustainable Development of Mountain Agriculture”, highlighting that it is crucial to raise awareness internationally on opportunities for sustainable mountain agriculture development for diversified and sustainable food systems. Finally, Daniel Gustafson, FAO’s Deputy Director-General, raised concerns for the existing imbalance between the recognition of mountains internationally and their importance. He advocated for increased joint efforts to add-value to mountain products and to empower mountain people, particularly women. Prof Hui Wu, Vice President, UIR, also offered a closing remark thanking everyone for taking collective efforts in this important area for Zero Hunger.

The challenges and problems facing sustainable mountain ecosystems and mountain agriculture are often complex, transboundary and difficult to be resolved by a single country, a single discipline, or single institution. All national and international partners from different backgrounds have emphasized the need to team up and continue flying the flag for supporting mountain agriculture and mountain people in the Asia region. There is a need to reach out further and communicate globally to increase multisectoral policy prioritization, interdisciplinary engagement, and public–private investment for the development of sustainable mountain agriculture.

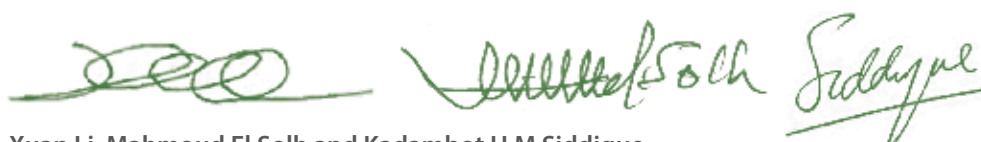
This publication, titled “Mountain agriculture-opportunities for harnessing Zero Hunger in Asia” integrates and moves the outcomes of the Mountain Consultation forward by looking at the status, challenges, opportunities and solutions of sustainable mountain agriculture development for Zero Hunger in Asia. It comprises four parts:

Part I sets the scene of the publication, serving as a guiding and introductory passage to outline the context and justification of why mountain agriculture matters and the synergies among mountain agriculture, food security and nutrition in a changing climate.

Part II comprises seven thematic chapters (Chapters 2–8) on mountain agriculture that are technical and multidisciplinary in nature with a regional and global outlook, but also practical in terms of conveying hands-on lessons-learned and successful case studies at the local level. They integrate mountain agriculture to rounded debates under a sustainable food system, including the challenges and opportunities that mountain agriculture offers, FSN governance, Future Smart Foods, farming systems, value chains, and socio-cultural livelihoods. They also lay the framework for mountain food security and nutrition governance based on a survey conducted in Asian countries.

Part III presents eight Asian country case studies on mountain agriculture, covering efforts made by the national government, as well as diverse mountain communities from the public and private sectors, ranging from classic examples of integrated farming systems to innovative new institutional designs, specifically tailored to local contexts and conditions. The country studies presented: (1) an overview of food security and mountain characteristics and the contributions of mountain agriculture in each country; (2) the status, challenges and constraints of mountain agriculture; (3) opportunities and entry points for mountain agriculture development to address Zero Hunger and poverty reduction (from food system perspectives covering production, agro-processing, marketing and consumption); (4) country experiences: main policy measures, initiatives and practices to enhance mountain agriculture development; (5) strategic consideration and suggestions: policies and measures, and governance promoting sustainable agriculture development in mountain areas; (5) conclusion.

Part IV concludes the publication with a set of Recommendations to inform the policymakers, development experts, academics and mountain communities who support sustainable mountain development, food security and nutrition. The Recommendations were developed by Mahmoud El Solh, in collaboration with a large group of multidisciplinary, international experts, to put the development of mountain agriculture on a more significant and sustainable path and make it an integral part of the food security and nutrition policy nationally and globally.



Xuan Li, Mahmoud El Solh and Kadambot H.M Siddique
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Acronyms and abbreviations

ABDP	Agrobiodiversity Policy, Nepal
ABP	Agribusiness Promotion Policy, Nepal
ADB	Asian Development Bank
ADS	Agriculture Development Strategy
AEC	Agro-enterprise Centre, Nepal
AEZ	agro-ecological zones
AFSP	Agriculture Food Security Project
AJK	Azad, Jammu and Kashmir
APP	Agricultural Perspective Plan, Nepal
ASEAN	Association of South East Asian Nations
BARDC	Balochistan Agricultural Research and Development Center
BINA	Bangladesh Institute of Nuclear Agriculture
BOT	Build Operate Transfer
BWDB	Bangladesh Water Development Board
CAAS	Chinese Academy of Agriculture Sciences
CBN	Cost of Basic Need
CBO	community based organizations
CFS	Committee on World Food Security
CGIAR	Center of the Consultative Group for International Agricultural Research
CHT	Chittagong Hill Tracts
CPS	common property resources
DADOs	District Agriculture Development Offices, Nepal
DAE	Department of Agricultural Extension
DESTEP	Decentralized Science, Technology, Education Program
DEVCOM-Pakistan	Development Communications Network
DFTQC	Department of Food Technology and Quality Control, Nepal
DLRF	District Land Rights Forum
DLSO	District Livestock Services Offices, Nepal
DMARD	Department of Agriculture and Rural Development, Viet Nam
ECDF	Environment Conservation and Development Forum
EU	European Union
FANUSEP	Food and Nutrition Security Program, Nepal
FAO	Food and Agricultural Organization of the United Nations
FATA	Federal Administered Tribal Areas
FFS	Farmer Field Schools
FNCCI	Nepalese Chamber of Commerce and Industries
FSA	Food Security Analysis
FSI	Forest Survey of India
FPO	Fruit Products Order
FSF	Future Smart Food
GAP	Good Agricultural Practices

GDP	Gross Domestic Product
GIAHS	Global Important Agricultural Heritage Systems
GSO	General Statistics Office, Viet Nam
HACCP	Hazard Analysis and Critical Control Points
HADP	Hill Area Development Programme
HDI	Human Development Index
HIMALI	High Mountain Agri-business and Livelihood Improvement Project, Nepal
HKH	Hindu Kush Himalayan
HLPE	High Level Panel of Experts
HVAP	High Value Agriculture Project, Nepal
HYV	High Yielding Varieties
ICESCR	International Covenant on Economic Social and Cultural Rights
ICIMOD	International Centre for Integrated Mountain Development
ICRISAT	International Crops Research Institute for the Semi-Arid Tropics
ICT	Information and Communications Technology
IDM	International Day of Mountains
IFAD	International Fund for Agricultural Development
INAGEP	Innovation and Agro-entrepreneurship Program
IPCC	Intergovernmental Panel on Climate Change
IPM	Integrated Pest Management
IUCN	International Union for Conservation of Nature
KHAE	Kanchenjunga Himalica Agriculture Enterprise
LDC	Least Developed Country
LER	local elevation radius
LIT	low-input technology
MAF	Ministry of Agriculture and Forestry
MAPs	Medical Aromatic Plants
masl	metres above sea level
MDG1	1 st Millennium Development Goals
MEAs	Multilateral Environmental Agreements
MFA	multifunctionality of agriculture
MNFSR	Ministry of National Food Security and Research, Pakistan
MOCHTA	Ministry of Chittagong Hill Tracts Affairs
MoALD	Ministry of Agriculture and Livestock Development
MoALMC	Ministry of Agriculture, Land Management and Co-operatives, Nepal
MOLISA	Ministry of Labour Invalids and Social Affairs, Viet Nam
MP	Mountain Partnership
MPP	Mountain Partnership Products
MPLCS	Myanmar Poverty and Living Condition Survey
MSNP	Multi-Sector Nutrition Plan, Nepal
NAFES	National Agriculture and Forestry Services
NAFRI	National Agriculture Forestry Research Institute
NAP	National Agriculture Policy, Nepal
NARC	National Agriculture Research Council
NDMA	National Disaster Management Authority
NIDA-Pakistan	National Integrated Development Association
NLRF	National Land Rights Forum, Nepal

NLSS	Nepal Living Standards Survey
NNSPA	National Nutrition Strategy and Plan of Action
NOMAFSI	Northern Mountainous Agriculture and Forestry Science Institute, Viet Nam
NPV	net present value
NSEDP	National Socio-Economic Development Plan
NTB	Nepal Tourism Board
NTFP	non-timber forest products
NUS	Neglected and Underutilized species
OVOP	One Village One Product
PARC	Pakistan Agricultural Research Council
PDR	People's Democratic Republic, Lao PDR
PGS	Participatory Guarantee System
PMAMP	Prime Minister Agriculture Modernizing Project, Nepal
POP	Package of Practices
PoU	Prevalence of Undernourishment
PPP	purchasing power parity
PPC	Primary Processing Centres
PSL	Priority Sector Lending
PWD	Public Works Department
RAP-FAO	Regional Office for Asia and Pacific
RISMFP	Rising Income of Small and Marginal Farmers Project, Nepal
RI-ZH	Regional Initiative on Zero Hunger
SAARC	South Asian Association for Regional Cooperation
SAI	State Agriculture Institutes
SALT	Sloping Agricultural Land Technology
SDGs	Sustainable Development Goals
SEC	small ethnic communities
SEZ	Special Economic Zones
SRI	System of Rice Intensification
SSR	Self Sufficiency Rate
SWG	Sector Working Groups
SWOT	Strengths, Weakness, Opportunity and Threat
TAAN	Trekking Agencies' Association of Nepal
UFE	Under-Forestry Economy
UNDP	United Nations Development Programme
UNEP	United Nations Environment Programme
USGS	United States Geological Survey
UIR	University of International Relations of China
UFE	Under-Forestry Economy
VAAS	Vietnam Academy of Agricultural Sciences
VADEP	Value Chain Development Program, Nepal
VKC	Village Knowledge Centres
WEF	Water-Energy-Food
WFP	World Food Programme
WHO	World Health Organization
ZHC	Zero Hunger Challenge
ZTBL	Zari Taraqiati Bank Limited



Executive summary

Part I Setting the scene

Chapter 1 Introduction: mountain agriculture: opportunities for harnessing Zero Hunger in Asia, by Xuan Li, Kadambot H.M. Siddique, Mahmoud El Solh and Thomas Hofer, sets the scene and contexts of the whole publication with a focus on mountain agriculture, food security and nutrition from a Zero Hunger perspective.

This chapter sets the scene for the entire publication, which presents a regional overview on mountain agriculture development based on thematic analysis, national studies, and the set of Recommendations on developing sustainable mountain agriculture. It starts with contextualizing why mountain agriculture deserves special attention for Zero Hunger in Asia. It then demonstrates the agroclimatic distinctions between mountains and plains, which implies both challenges and opportunities for mountain agriculture. Moreover, it focuses on the opportunities that mountain agriculture can bring to achieving Zero Hunger with evidence in Asia, examining the subject from four dimensions of food security – to enhance availability, access, utilization and stability of sufficient, safe and nutritious food. Furthermore, it gives a snapshot of the International Workshop and Regional Expert Consultation on Strengthening Mountain Agriculture Development and Food Security and Nutrition Governance which was co-organized by FAO and UIR, in collaboration with various partners, to better understand the challenges and opportunities that mountain agriculture faces and offers, as well as identifying the possible entry points to turn challenges into potential opportunities.

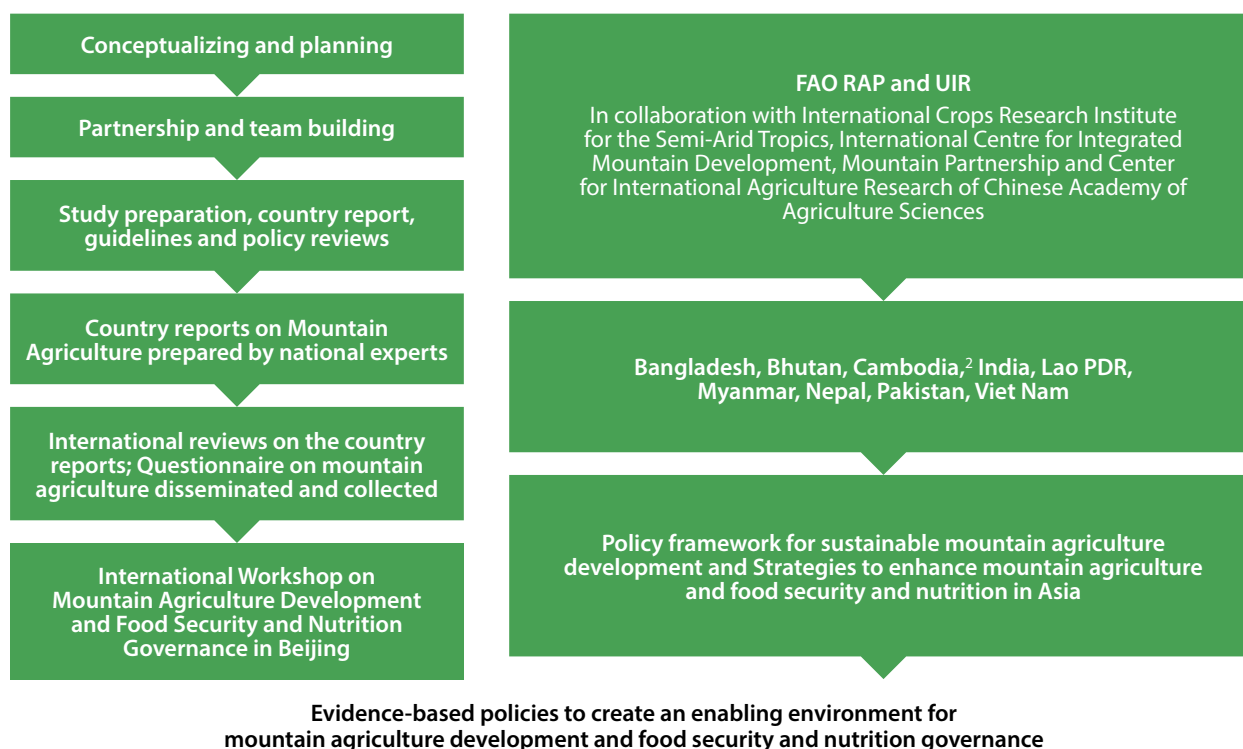
Why does mountain agriculture deserve special attention for Zero Hunger in Asia: Firstly, mountain populations in Asia are face many challenges when it comes to food supply and malnutrition: more than 192 million mountain people in Asia were considered vulnerable to food insecurity in 2012. Secondly, mountains ranges are by no means insignificant in Asia: Asia hosts more than one-third of the world's mountains and many Asian countries are dominated by mountains ranges. Thirdly, the livelihoods of most mountain dwellers depend heavily on agriculture in Asia with little option to derive from other sources. This means that strengthening mountain agriculture must be a priority for achieving Zero Hunger.

This chapter focuses on opportunities that mountain biodiversity offers for agriculture to achieve Zero Hunger and improve food security from its four dimensions:

1) availability, 2) access, 3) utilization and 4) stability of sufficient, safe and nutritious food. In terms of food availability, mountain agriculture has a substantial comparative advantage when it comes to increasing agricultural production of sufficient, nutritious and safe food based on the vast but underdeveloped land areas, high level of topology diversity, agro-climate specifics of mountain regions, and different growing seasons. In terms of food access, mountain agricultural production has the potential to sustain household food needs, with surplus produce that can be bartered for food or non-food items. Increasing levels of monetary income can lead to cash availability for mountain households to purchase food items and therefore make better food access possible. In terms of food utilization, which concerns the nutritional status of individuals, special and diversified mountain agroclimatic conditions enable mountain agriculture to produce a wide variety of food products to diversify diets for nutritional improvement. In terms of stability, mountain agriculture offers unique opportunities for filling the gap that results from adverse weather conditions, political instability or other unforeseen factors. However, considering the existing obstacles in terms of topography, climate, remoteness, etc, **mountain agriculture requires much more attention in national and sub-national policies in order to bring its potential to full fruition and so improve the livelihood situation of mountain communities.**

This chapter also introduces the background of the report – the International Workshop and Regional Expert Consultation on Strengthening Mountain Agriculture Development and Food Security and Nutrition Governance. (Figure ES.1). This was organized by FAO and UIR, together with its partners to better understand the challenges and opportunities that mountain agriculture faces and offers, as well as identifying the possible entry points to turn challenges into opportunities. **Besides 8 comprehensive country studies on mountain agriculture (Chapter 9-16), the major outcomes of the International Workshop and Regional Expert Consultation event are: the Recommendations for sustainable development of**

Figure ES.1 The development process of the Mountain Consultation



mountain agriculture to enhance food security and nutrition (Chapter 17), and the Policy Framework for sustainable mountain agriculture development (Chapter 8).

In the context of the SDGs and turning the challenges of mountain agriculture into opportunities, promoting Future Smart Food (FSF) which are adapted to mountain cultivation is considered an entry point. FAO, defines Future Smart Food as Neglected and Underutilized Species (NUS) that are nutrition-dense, climate-resilient, economically-viable and locally available or adaptable.

This is because mountains host approximately one-quarter of all terrestrial biodiversity and nearly half of the world's biodiversity hotspots. But to ensure such FSF schemes thrive, government will have to take a leading role and place mountain agriculture at the centre of their national and sub-national poverty reduction, food security and nutrition policies. It is only with full government backing that mountain agriculture will achieve its potential improve the livelihood of mountain people. This publication presents a regional overview on mountain agriculture development based on thematic analysis and national studies.

Part II Enabling environment to promote sustainable mountain agriculture development

Based on the analysis on the challenges and opportunities that mountain agriculture entail (Chapter 2), Part II navigates through multiple areas of mountain agriculture in the food systems (Chapter 3–7), to develop a policy framework for sustainable mountain agriculture (Chapter 8). In short, Part II includes seven thematic chapters on the features, challenges, opportunities, case studies and strategies related to the enabling environments required to promote sustainable mountain agricultural development from a food system perspective.

Chapter 2 The status, opportunities and challenges of mountain agriculture development to improve livelihoods and ensure food security and Zero Hunger, by Mahmoud El Solh provides a deep but broad overview of challenges and opportunities of mountain agriculture and farming to improve food security and livelihoods.

The chapter first provides a sketch of the importance of mountain ecosystems for meeting the global Sustainable Development Goal (SDG) challenges on environment, food security and livelihoods, with a highlight on mountain's special contribution to the water-energy-food nexus. The chapter then examines mountain agriculture's specific challenges, major

² The country study from Cambodia is not included in this publication due to limited national data on mountain agriculture available. To access the presentation from Cambodia at the Mountain Consultation, please visit the website on Regional initiative of Zero Hunger at FAO RAP.

production systems and added-value products. These characteristics and different categories of productions systems and products were explained in detail with reference to examples around Asia. The chapter then reviews the role of the UN and other international organizations in enhancing mountain ecosystems and agriculture. There is also a call for international cooperation to tackle the trans-boundary challenges and strengthen mountain agriculture development. A set of recommendations are also included at the end of the chapter.

Mountain areas are characterized by topography of variable altitudes and variable climatic conditions and so are major reservoirs of global biodiversity. Mountain areas are rich in biodiversity, containing one-third of all plant species and hosting 17 (50 percent) of the 34 global biodiversity hotspots. In additions, one of the other important ecosystem contributions that mountain provides, is the water-energy-food nexus. Positive impacts resulting from these policies and actions are essential for reaching the SDGs, including the reduction of poverty and the elimination of hunger at national and global levels.

One of the major difficulties in developing mountain agriculture is the vicious cycle of poverty – natural resource degradation – poverty that exists in many mountain regions. Basically, the higher the poverty level in a mountain community, the greater the exploitation of natural resources, namely soil, water and biodiversity. There are four major production systems in mountain agriculture: (1) pastoral livestock production system; (2) agro-pastoral production system; (3) rain-fed agricultural production system, including fruit trees; (4) irrigated agriculture production systems. This chapter provides detailed technical insights into the involved natural resource, socioeconomic, market and policy factors of each of the production systems with country cases. In general, mountain agriculture production systems are highly diversified and make use of integrated cropping systems in the forms of smallholder and family farming.

Access to markets is an issue in mountain agriculture due to lack of infrastructure and transportation. However, added-value products by mountain agriculture are an important and useful way of increasing income and improving livelihoods in isolated low-income mountain communities. Added-value products in livestock-based production systems (in both pastoral and agropastoral livestock production systems) include dairy products such as yogurt and cheese produced from cow, goat and sheeps' milk. It is important to

train people, particularly women, on how to produce high-quality hygienic yogurt and cheese which can fetch high market prices and increase the income of mountain communities. Examples of successful stories of wool, walnuts, fresh mint and other Future Smart Food varieties are briefly introduced and explained.

The chapter summarizes the role of the UN agencies, FAO, Mountain Partnership, ICIMOD and other major institutions' contribution to mountain agriculture. It calls for more collaboration and meaningful technical, policy and financial investment in mountain agriculture development. The sustainable development of mountain agriculture requires long-term investment in holistic and integrated approaches that involve policy, socio-economic and institutional aspects; natural resource management; and crop and livestock improvement. (Figure ES.2).

Chapter 3 The potential of Future Smart Food for mountain agriculture: nutrition, climate-resilient, economic and social benefits, by Kadambot H.M

Siddique and Xuan Li, introduces the concept of Future Smart Food and explores how developing Future Smart Food in mountain agriculture can transform the mountain food systems so that they are more nutrition sensitive, climate resilient, economically viable and locally adaptable.

This chapter starts with the context of major challenges faced by mountain agriculture, challenges which will require the transformation of mountain agriculture from using staple-oriented systems to being more nutrition-sensitive and climate-smart. To show how this is possible, the chapter presents the concept and features of FSF and shows how by making use of such crops, mountain agriculture can help to meet the Zero Hunger goals. On this basis, it analyzes how to mainstream FSF and harness the opportunities they can offer mountain agriculture development, especially in terms of the entry points and government leadership.

FSF is a term used for NUS that are nutrient-dense, climate-resilient, economically viable, and locally available or adaptable. Many countries in Asia have identified the following as Future Smart Food: pulses, cowpea, taro, millets, drumstick, quinoa, buckwheat and moringa. Future Smart Food is key to agricultural diversification and play a significant role in narrowing and closing production and nutritional gaps. Led by FAO RAP since 2016, the FSF initiative has gained a wide range of national and international partners and has been received favourably by academics, policy makers and has attracted broader public attention.

Figure ES.2 Development stages of food systems for Future Smart Food



The main multi-dimensional benefits that FSFs with mountain specialty offer are: (1) they are nutrient dense, rich in macronutrients and micronutrients, relative to the staple food crops of mountain populations; (2) they are climate resilient for climate change adaptability in the mountains, to enhance diversification and resilience of agroecosystems and they have the ability to grow on marginal land and withstand the impact of climate change scenarios (e.g. drought, cold, increased frequency and intensity of extreme weather events); (3) FSFs are economically viable, providing income opportunities for mountain populations and contributing to mountain livelihood improvement based on their higher nutritional and health value. They can also offer a higher level of safety being organic and can supplement year round incomes when grown as off-season products; (4) they are locally available or adaptable, and take into account the traditional knowledge and the cultural identity of indigenous mountain people.

But how to harness the potential of FSFs for mountain agriculture development? From a food system perspective, transforming mountain agriculture and food systems so that they are more diversified, nutrition-sensitive, climate-resilient, economically viable and locally-adaptable is the key to harnessing the potential of FSFs, particularly if they can be mainstreamed. To tap into the opportunities that FSFs offer for mountain agriculture achieving Zero Hunger, focus should be given to identifying and prioritizing FSFs with local mountain specialty in terms of (1) Prioritization: identify and prioritize FSFs with mountain specialty; (2) Production: increase production of mountain FSFs in mountain farming systems adaptable to various agro-ecological zones; (3) Processing: improve the efficiency of post-harvest and processing of FSFs with mountain specialty; (4) Marketing: promote the distribution and marketing of FSFs with mountain specialty; (5) Consumption: Increase the demand for FSFs with mountain specialty among consumers by increasing awareness and knowledge about their multi-dimensional benefits (Figure ES.3). Government leadership will be indispensable to this end.

Chapter 4 Integrated farming system development for mountain agriculture in Asia, by **Prakash C.Tiwari, Liqun Wang, and Bhagwati Joshi** provides an overview of the challenges and future development of diverse

farming systems in mountains in Asia, covering all land based activities such as agronomic or field crops, horticulture, animal husbandry, poultry and fisheries. It also covers types of conservation practice and their organic and functional links.

The chapter first examines the principle Asian mountain ranges including the Hindu Kush Himalaya, the highlands of Central Asia, the plateau of Tibet and Magnolia and the uplands of Southeast Asia. It then looks at the characteristics of cropping systems in four major Asian mountain integrated farming systems. The chapter also provides analysis of the constraints and emerging threats to these integrated farming systems, as well as approaches of how mountain farming systems can be restored and developed. A section looking at the under-forestry-economy in China is included before the conclusion.

The principal mountain farming systems of Asia are as follows: (1) Himalayan Farming Systems (including a mixed crop livestock farming system, a livestock-pasture farming system and shifting cultivation); (2) Upland Intensive Mixed Farming Systems; (3) Highland Extensive Mixed Farming System; and (4) a Pastoral Farming System. The mountain regions of Asia therefore provide some of the best examples of integrated mountain farming systems.

However, over recent years, the values of traditional mountain farming systems have eroded mainly due to population growth, rapid urbanization, depletion of the natural resource base, economic globalization, market influences and the effects of climate change. However, capitalizing upon both the sociocultural and biophysical strength of the mountain landscape, integrated farming systems have the potential to contribute significantly towards attaining food and nutrition security as well as securing improved and viable livelihood opportunities for mountain communities. The potential of agroclimatic diversity in mountain areas ranging from productive valleys to higher elevation can be optimally utilized for the diversification and integration of agronomic or field crops, livestock farming, horticulture, floriculture, dairying, fishing, bee-keeping and forestry at watershed level. The development of value-addition products would be necessary for ensuring the sustainability of the entire integrated mountain production system in mountain areas.

This chapter also includes a case study on Under-Forestry Economy (UFE) in China. The development of UFE contributes to the improvement of farmers' income and rural livelihoods by increasing productivity and profitability of the systems. The related research and assessment results show that the development of the UFE can enhance the income growth of farmers, especially the income growth of low- and middle-income farmers, which means that this integrating practice plays a significant role not only in addressing hunger and malnutrition in poor hill and mountain areas, but also in promoting rural development. Moreover, the development of UFE plays a positive role in protecting the ecological environment and in forming into a multilevel green activity on the landscape through protection of forest resources. Government leadership and choosing the suitable development model is crucial in this success. In addition, integration of the different sectors of mountain economy with local agricultural production systems, the flow of credit to rural areas, and increased investment in mountain agricultural enterprises will help in making all types of mountain farming systems economically viable and ecologically sustainable.

Chapter 5 Sustainable mountain agriculture through integrated and science-based watershed management: a case study, by **Suhas P. Wani** and **Dinesh K. Marothia** is a technical contribution on how an integrated watershed management of mountain agriculture can tackle the traditional problems that mountain agriculture has faced, and provide accessible solutions for mountain populations to increase their food security and income levels while retaining their social traditions and respecting the natural resources and ecosystems of mountains.

The chapter first introduces the concept and benefits of participatory, integrated and consortium approaches for watershed management, which could enhance productivity and resilience, improve water budgeting and management strategy. The chapter showcases these advantages through a case study in Lucheba watershed in China. The historical context, cropping systems and forage production and animal-based livelihoods of the Lucheba watershed are included in the study. Special analysis is given to the input utilization, output and income patterns in crop production, emerging market patterns and employment as well as income from farm and non-farm activities. The chapter concludes with key factors that can ensure a successful integrated watershed management and value chain approach.

An integrated watershed management approach provides an entry point for improving food security and livelihoods in mountainous areas. Such an approach also helps to address the issues of sustainable environmental services and climate change and helps to build the resilience of food systems. FSF, which are climate resilient, locally grown, nutritious and ecologically sound, can also help meet the Zero Hunger target. The 50 million tourists who visit mountain regions annually are also a potential way of popularizing FSF and creating extra income and investment for local people.

The case study of the Lucheba watershed in Guizhou Province in southern China clearly illustrates the benefits of adopting a holistic, integrated watershed management approach to improving farmers' income and achieving better food security. In addition, the approach has helped to develop water resources through catchment management and by reducing water scarcity during dry periods. The watershed management approach has created net present value (NPV) of USD 14.7 million over 10 years with an investment of USD 4.5 million by increasing cropping intensity to 300 percent and creating new links with markets.

Thanks to the increased income from agriculture, most houses in Lucheba are newly constructed with concrete and have the sort of amenities that were, until recently, only seen in urban areas. Farmers now work more collectively having formed a Farmers Association and through the use of new technologies, such as the Internet, they are able to sell vegetables in markets further afield, such as Shanghai and Hong Kong. Per capita income in Lucheba village increased from CNY 6 800 per year in 2011 to CNY 8 100 per year in 2012, which was twice the provincial per capita income. The many impacts of integrated watershed management at Lucheba will be looked at in more detail throughout this chapter, not only in social terms but also in relation to the environment, the economy and the region's food security.

Chapter 6 Integrated value-chain development of mountain products for poverty reduction and Zero Hunger by **Surendra R Joshi**, **Michelle Geringer** and **Bingchuan Hu** utilized the approach of integrated value-chain development and applied it to mountain development based on mountain region's advantages of diversification and value-added products.

The chapter first examines the mountain context and key issues before it moves to introducing high value mountain products, the market opportunities they offer and the many challenges in developing mountain agriculture. The chapter then introduces the integrated value chain development approach as the most effective way of improving mountain food security and building resilient communities in mountain regions. Case studies about the e-commerce development of agricultural products in China, large cardamom pods value chain development in Nepal and the Mountain Partnership Products Initiative (MPP Initiative) are presented to conclude that mountain products have a key role to play in sustainable food systems and improving livelihoods. Not only do they contribute to food security and sustainable food diets, but they are also a means of improving local economies, livelihoods, preserving agrobiodiversity and mountain peoples' diverse heritage.

For centuries, mountain communities have tapped into their natural resources and built expertise to produce high-quality and unique products such as coffee, cheese, grains, herbs, medicinal plants and spices as well as handicrafts. While small-scale mountain agriculture cannot compete with the volume of lowland production, it can focus on diversification and has the potential to tap into mountain specialty products markets such as organic, fair trade or high-end quality markets and in doing so, fetch premium prices. All evidence shows that high value products can contribute greatly to the economy of mountain areas.

Considering that mountain agriculture is highly diverse, small-scale and inherently green, the MPP Initiative and other organizations such as the ICIMOD strive to create demand for high-quality traditional mountain products, harness comparative advantages and create fair incentives/compensation for mountain farmers, particularly for women, who are often left to manage the farms and households when men migrate to lowland areas in search of additional sources of income. An increased demand for traditional mountain products can increase their income through trade and manufacturing.

The integrated value-chain development approach is a market driven systems approach, which focuses on linking households and/or communities to growing markets, so that they can earn income to purchase additional food while reducing the risks that come with relying solely on their own production. This will be done by striking the balance between improving productivity while ensuring market functionality and sustainability. It emphasizes specific opportunities (e.g. the

comparative and competitive advantages of mountain products and services) and challenges to achieving sustainable and inclusive growth.

Within the integrated value-chain development, E-commerce is gaining popularity as a tool for marketing agricultural products in many countries. For example, in China there are some innovative e-commerce models such as "social e-commerce", and Tik Tok – a media app for creating and sharing short videos – that have brought many positive effects, which include responsible production, environmental protection and sustainable development. Other successful case studies are the large cardamom pods in Nepal related in the ICIMOD Himalica Programme and MPP's Jumla's mixed beans story. They have demonstrated that an integrated value-chain development approach can contribute to reducing poverty and contribute to Zero Hunger, thereby creating shared value through strengthening producers and their groups and organizations to acquire agricultural inputs collectively at lower prices, and helping them to add value and commercialize their products.

Chapter 7 Global Important Agricultural Heritage Systems (GIAHS) and their role in integrated mountain agricultural development, by Qingwen

Min, Heyao Li and Lubin Ding illustrates how GIAHS can turn the potential of mountain agriculture into tangible benefits for farmers' food security, cultural traditions and income, as well as offer benefits to the environment.

The chapter first introduces the concept and multi-functionality of GIAHS. It looks at mountainous areas with intensive GIAHS or potential sites. After describing traditional and ingenious agricultural practices in mountainous areas, the chapter introduces three mountain GIAHS sites in China with their key agricultural functions, value-added products, contribution to ecosystems and environment as well as cultural importance. The case studies also highlight the importance of good governance and participation of multi-stakeholders. The chapter concludes with GIAHS's contribution to Zero Hunger and poverty reduction that they can achieve economic development through the development of multi-functional agriculture, extended value chain, and multi-participation benefit sharing mechanism.

As well as a comprehensive list, the chapter shows that although mountains are considered marginal land and unsuitable for modern commercial farming, among the designated GIAHS sites for the whole world, 60 percent of them are in mountainous areas, and the proportion

remains the same for China. It shows that mountain agriculture has great potential for ecosystem preservation and that mountain areas are hubs for plant diversity, cultural diversity and economic potential.

The chapter highlighted case studies in China with evidences from Honghe Hani Rice Terraces Systems; Congjiang Dong's Rice Fish Duck System; and Shaoxing Kuaijishan Ancient Chinese Torreya. For instance, in the Honghe Hani Rice Terraces System, there are 195 varieties of rice used in the area, including 48 kinds of local rice varieties. The local government pays great attention to the protection and utilization of traditional food crops, and through the establishment of germplasm resources and the promotion of marketization of red rice and purple rice, to achieve the goal of protection and poverty alleviation.

GIAHS are not only rich in resources, but also have a brand advantage. Studies have shown that the pollution-free environment of the GIAHS is suitable for the development of organic production. Endemic plant and animal varieties with the GIAHS brand have higher market value than general varieties. For example, red rice grown in the Hani Rice Terraces System is labeled with national geographical indications and is used as a raw material to manufacture distinctive ecological products. Agricultural organic certification, based on traditional environmentally friendly technology, increases farmer income and encourages traditional agricultural techniques and preserves cultural heritage. In addition, GIAHS area farmers can benefit from tourists who often like to buy local agricultural products when visiting and taking part in tourist activities. The sustainable agriculture in GIAHS sites relies on traditional methods of production, which keeps and improves local biodiversity and develops production and processing of high quality traditional local products, rural tourism and handicrafts.

The designation and conservation of GIAHS is conducive to the recognition and activation of local governments to adopt laws, policies, documents to guarantee and accelerate the dynamic conservation and sustainable development of GIAHS sites. The government's leadership in creating an enabling environment is essential to make sure that the five key elements of the mountain heritage system (forests villages, terraces, water and culture) are developed in balance. In addition, the designation and conservation of GIAHS is also a process of multi-participation and coordination. The participation of multi-stakeholders helps to optimize the value distribution and construction of value chains, motivate all players and can create new points of growth and promote the value-addition of the GIAHS sites.

Chapter 8 Strengthening the governance of mountain agriculture and food security and nutrition – An analysis of survey on mountain agriculture in Asia, by Xuan Li and Luis Antonio T.

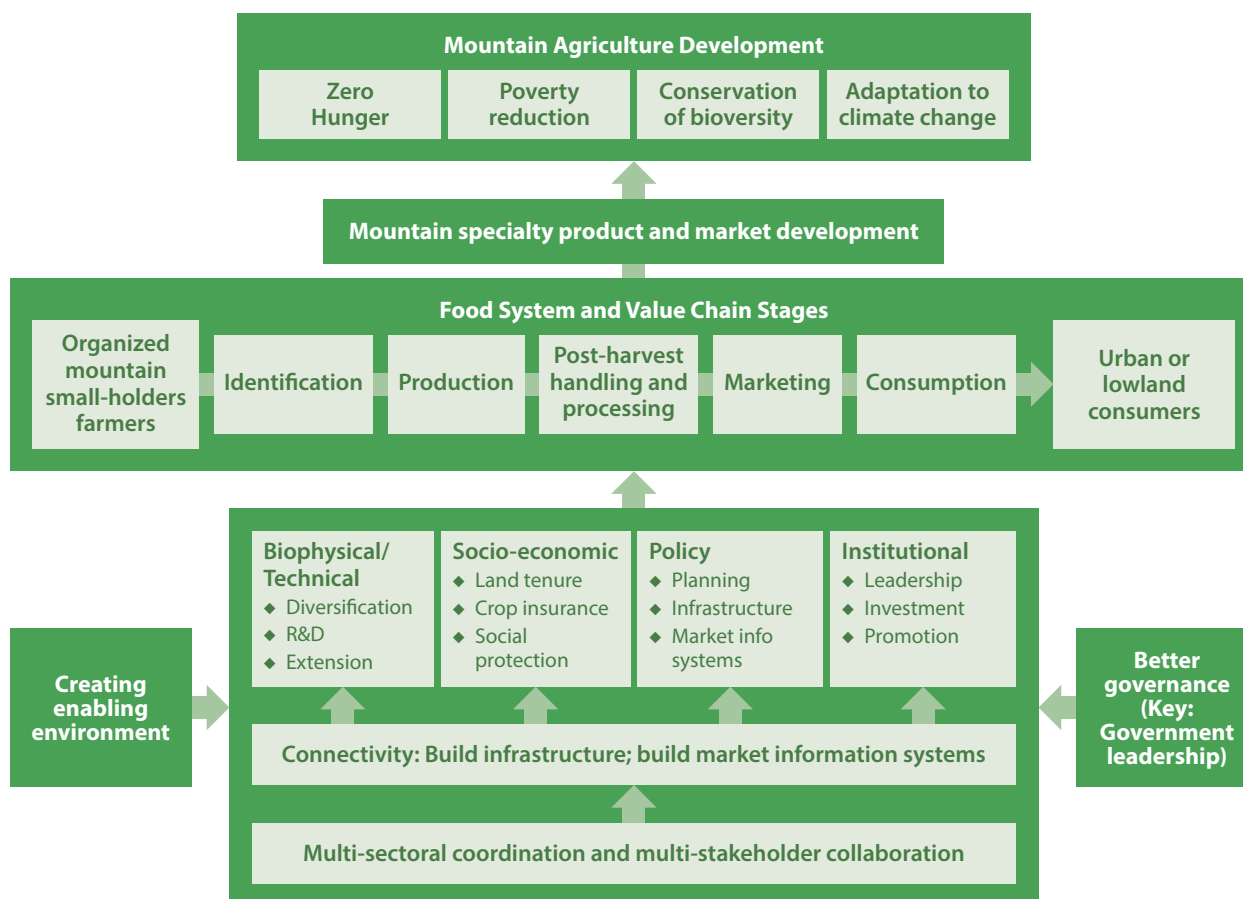
Hualda presents the FAO survey on mountain agriculture and its analysis, results and governance implications. It emphasizes the need to develop a policy framework for mountain agriculture development based on food systems and a value chain approach with guiding principles, and highlights the responsibility of the Government to create an enabling environment for sustainable mountain agriculture development.

This chapter first recognizes that while challenges and potentials co-exist in the mountains, it requires in-depth understanding of the multi-dimensional constraints for mountain agriculture at a country level. It then gives the background about the survey conducted on mountain agriculture in Asian countries, i.e. Bangladesh, Bhutan, Cambodia, India, Lao PDR, Myanmar, Nepal, Pakistan and Viet Nam. The chapter then goes on to present the analysis and results of the survey in terms of the main constraints in biophysical-technical, socio-economic, policy and institutional dimensions. It further presents the results of suggested solutions to address these multi-dimensional constraints facing sustainable mountain agriculture development. On this basis, a policy framework is suggested to rationalize strategies and priorities for sustainable mountain agriculture development.

The survey shows the results of the four-dimensional constraints. In terms of biophysical-technical constraints, "seasonal hazards" and "poor infrastructure" are identified as most important challenges. In terms of socio-economic constraints, "lack of market information" and "poor access to telecommunications" are identified as most important challenges, followed by "isolation and lack of market access/transport network". In terms of policy constraints, "lack of information and policy support on mountain specialty products" are identified as main challenges. In terms of institutional constraints, "lack of organized institutional support to connect value chain components namely production, processing, marketing and consumption for mountain regions" is identified as most important issue. In short, constraints that were given priority by respondents were those relating to the development of mountain specialty products and to improving opportunities to link with markets.

The survey emphasized that to address multi-dimensional constraints on mountain agriculture development, the most important issues were related to mountain products and market development. Based

Figure ES.3 Policy framework for sustainable mountain agriculture development



on the suggested solutions, developing markets for mountain specialty products may be considered as main strategy or “driver” for strengthening sustainable mountain agriculture development. Other identified issues and constraints are linked to product and market development.

To turn challenges into opportunities in mountain areas, it requires multi-dimensional interventions that are rationalized and coordinated through a “driver” strategy to address challenges in mountain areas. From a food system and value chain perspective, the priority should be given to focus on mountain specialty products (e.g. FSF with mountain speciality) with respect to identification, production, post-harvest handling, marketing and consumption. In short, identifying/prioritizing mountain speciality products is a starting point, but emphasis should be given to each

stage of the food system and value chain to build strong connectivity between the stages and to bridge gaps between mountains and markets.

To create an enabling environment to turn challenges into opportunities in mountain areas, a policy framework should be established and developed for mountain agriculture development based on food systems and a value chain approach with guiding principles (Figure ES.4). It is the government’s responsibility to create an enabling environment conducive to mountain agriculture development. Governments support, especially local governments, is essential for turning these challenges into opportunities, by organizing and mobilizing resources to tap into opportunities and generate outcomes conducive to local development in mountain areas.

Part III Country studies on mountain agriculture development

(Chapter 9 through Chapter 16) includes eight Country Studies on Mountain Agriculture Development (Bhutan, Nepal, Myanmar, Vietnam, Lao PDR, India, Pakistan and Bangladesh) (Figure ES.4). The country studies covers efforts made by national governments and includes input from diverse mountain communities and the public and private sector. The studies also look at integrated farming systems that use innovative new methods that can be specifically tailored to local contexts and conditions. Each of the country studies include five sections: (1) an overview of food security and mountain characteristics and the contributions/percentage of mountain agriculture in the country; (2) the status, challenges and constraints of mountain agriculture; (3) opportunities and entry points for mountain agriculture development to address Zero Hunger and poverty reduction (food systems perspectives covering production, agroprocessing, marketing and consumption); (4) the country experience: main policies measures, initiatives and practices in mountain agriculture development; (5) Strategic consideration and suggestions: policies and measures, governance promoting sustainable agriculture development in mountain areas; and (5) conclusion.

Figure ES.4 The coverage of Asian countries in the country studies on Mountain Agriculture Development



Source: United Nations Map No 4170 Rev. 17 (www.un.org/Depts/Cartographic/map/profile/world.pdf)

Note: Dashed lines on maps represent approximate border lines for which there may not yet be full agreement

Chapter 9 Bangladesh, by Prakash Kanti Chowdhury

presents the mountain agriculture challenges, opportunities and policy entry points of the Chittagong Hill Tracts (CHTs) which cover almost one-tenth of the whole country and are one of the most economically backwards regions of the country, with one of the highest malnutrition levels in the world. The lean season occurs from May to August; however, due to the high risk of natural hazards during the monsoon, it often extends into September. Each year it is more difficult for people to cope with the lean season, as food stocks from the previous harvest are limited, employment opportunities are few and purchasing power is low.

In terms of agriculture in the CHTs, the hills offer vast scope for the cultivation of a diverse mix of crops – cereals, pulses, oilseeds, vegetables, flowers and fruits. In addition, animal husbandry is an integral part of local farming systems. The temperature and climatic conditions support the growth of certain fruits and vegetable crops that cannot be cultivated in the plains and the produce provides higher dividends to cultivators in the hills thereby raising their economic status. One of the major challenges are land rights. Much of the land of indigenous people is unregistered and liable to be lost to immigrants, particularly where road networks are developed; the insecurity of tenure reduces the

incentive for medium- to long-term investments, such as horticulture or timber. Instead, short-term investments in seasonal crops are promoted, which do not provide high incomes for households and are not environmentally beneficial.

Sustainable agriculture development in the mountains can be supported by enabling policy and institutional reforms, promoting mountain niche products like fruits, ensuring tenurial security, generating integrated demand driven technology and service delivery, enhancing access to production assets and resources, credit and markets, and capacity building of farmers with strategic considerations of mountain specificities, biophysical and socio-economic conditions and livelihood options of mountain people. The Ministry of Chittagong Hill Tracts Affairs (MOCHTA) is responsible for the planning, implementation, and monitoring of development programmes and projects in the CHT. However, the sectoral approach of line ministries and the fragmented work of different non-governmental organizations often leads to overlap and fails to produce the desired development outcomes. To ensure that development activities are more effective and sustainable, and to avoid duplication, MOCHTA should be entrusted with the full responsibility of coordinating development work in the CHT.

Chapter 10 Bhutan, by **Kiran Subedi, Sangay Chopel** and **Loday Phuntsho** highlights that Bhutan, as a landlocked mountain country, is known for its strict environmental conservation policies, with a constitutional mandate to maintain at least 60 percent forest coverage. Bhutan faces food insecurity and malnutrition challenges. The National Nutrition Survey of 2015 reported that of children under 5 years old 21.2 percent were stunted, the prevalence of wasting was 4.3 percent, 9 percent were underweight and 2 percent were overweight. The same survey found that the prevalence of anaemia was 43.8 percent for children aged 6 to 59 months, 31.3 percent for children and youth aged 10–19 years, 34.9 percent for non-pregnant women aged 15–49 years, 27.3 percent for pregnant women, and 7.8 percent for babies who had low birth weights.

Bhutanese agriculture is largely based on the traditional subsistence-oriented mixed farming system that integrates cropping, livestock rearing and forest products. Rice is the staple crop. Domestic production accounts for half of the rice requirement. The population, particularly the poor, consume maize and other minor cereals such as millets and buckwheat to supplement their carbohydrate requirement. The principal cash crops in temperate areas include apples and potatoes, and in

the sub-tropics, oranges, areca nut, cardamom and ginger are grown. Chilies and vegetables are other promising sources of revenue. Over one-third of Bhutanese households grow fruit, such as apples, oranges, peach, plum, persimmon, pear, banana and mango; and nuts, such as walnut hazelnut and betel nut. Domesticated animals include cattle, goat, sheep, poultry and pigs. There are also fisheries. With abundant forests, farmers derive benefits including wild edible mushrooms, bamboo and cane, fern and fuelwood (NSB, 2015).

The mountainous terrain and scattered settlements of Bhutan make agro-processing and value addition cumbersome and the transport of raw materials is expensive and produce can spoil due to roadblock delays. Setting up small-scale facilities will allow local produce to be sold within local regions. Most agricultural and livestock products are sold in raw form, so there is immense opportunity for value addition. The farm shops (government subsidized outlets for supply of farm inputs, groceries and last resort markets for farm produce) offer a buy-back mechanism to cushion farmers against price drops and market gluts. This mechanism needs fine-tuning. The initiative of One Geog (Sub-district) – One Product needs further investment especially in value addition, branding and marketing. Another successful country experience is the Good agricultural practices (GAP) on sustainable and integrated farming in mountain areas. Restrictions on the use of chemicals have helped to promote GAP in agriculture. Bio inputs need to be promoted. The conservation of traditional crop varieties and livestock breeds must continue. Sustainable land management practices must continue and expand.

Mountain agriculture has a unique set of challenges. Considering the limited area of cultivation in the Bhutanese mountains, vertical expansion in terms of productivity gains through agro-ecological intervention and sustainable practices will help to enhance food and nutrition security. Policies geared towards empowering the farming community need to be formulated and implemented. Bhutan's pristine environment and natural way of farming, coupled with support for enterprise farming, offer immense opportunities for making farming a profitable venture and a successful way of addressing poverty.

Chapter 11 India, by **Parshant Bakshi** and **Dinesh Kumar** write that mountain agriculture in India is widespread and varied and despite facing disproportional challenges compared to other agro-ecological regions. The chapter showcases highly promising success stories about crops such as strawberry,

sea buckthorn and cardamom as well as agroforestry systems that can increase the country's production of FSF while simultaneously protecting the country's resource base.

India has seven major mountain ranges with different characteristics, challenges and opportunities. Among these, the eastern extension of the Himalayas, the Purvanchal Range, is one of the wettest places on earth, and the Western Ghats constitute one of the globe's top ten biodiversity hotspots. However, due to their undulating topography, India's seven mountain ranges face immense challenges to develop their potential to produce Future Smart Food and simultaneously protect the resource base of the easily eroded soil and increasingly overexploited water resources.

The government has initiated a myriad of regionally targeted initiatives to encourage livelihoods based on the production of FSF in these challenging environments. Among these, strawberry farming has shown to increase farmers' income by up to 25 times compared to production systems prior to intensification. Similarly, cardamom agroforestry systems have become a mainstay of Sikkim's smallholders, supporting many livelihoods while maintaining a healthy forest environment. Lastly, sea-buckthorn production has become a mainstay of many farmers in Ladakh, a success that is showcased by the rising popularity of the Leh Berry brand that is marketing sea-buckthorn juice across the country.

The authors conclude that these success stories should encourage further investments in mountain agriculture with a special focus on the integration of different agricultural sectors such as forestry, livestock and crop production as well as more promote research into harnessing and protecting the natural resource base in a sustainable manner as water scarcity concerns continue to rise.

Chapter 12 Lao PDR, by **Bounthanh Keoboualapha** shares the experiences of how Lao PDR is developing mountain agriculture for Zero Hunger and how the nation is tackling common mountain challenges with country-specific tactics. Lao PDR is noted as having the highest percentage of steep land in the Asia and Pacific region with rich ethnic diversities. The chapter also notes that children in rural villages in the northern and southern mountain regions are more likely to be malnourished than those living in plains and urban areas and the central region. The poverty headcount rate in 2013 for the mountains (midland and upland) is high at 28 percent, which is higher than the national average

of 23.2 percent. And, while poverty rates in the mountains have declined faster than the country's average (around 12.1 percent vs. 10.3 percent), mountain poverty is still prevalent.

Diversification is crucial and a key measure in building nutrition level as well as resilience to climate risks. Some forms of traditional farming systems, like shifting cultivation, are highly resilient to a range of shocks and vulnerabilities influenced by external factors. Linking farmers with nutritious food, food safety, value-addition, and quality of life for food security requires "Good Agricultural Practices" (GAPs). In Lao PDR, GAPs are widely promoted to produce safe food, while conserving the environment and increasing the income of farmers. For instance, in the Huaphan province in Northern Lao PDR, benzoin production from indigenous trees were supported by the government to increase cash income for mountain communities. The blend of indigenous technical knowledge and modern tree planting techniques to produce an export product with a ready market is increasingly attractive to farmers. They also benefit from technical assistance related to value-added processing at the family and community levels.

Socio-economic development for agricultural diversification and intensification with increased production and productivity, improved value-addition, and expanded marketing and sales has occurred in the flatlands along the Mekong corridor. The upland mountains have not benefited as expected despite the abundant agricultural production base and rich natural resource endowments which offer great potential for agricultural diversification and intensification. In rural mountainous areas, acute poverty, chronic malnutrition and natural resource degradation are still prevalent. Rural development addressing the current poverty and malnutrition rate to end poverty and achieve Zero Hunger would require more targeted, multi-sectoral and interdisciplinary efforts in terms of research and development, and monitoring and evaluation. The supports from development partners will be crucial as Lao PDR has committed to graduate from the Least Developed Country status by 2020 and mountain agriculture can help the nation achieve this aim.

Chapter 13 Myanmar, by **Sai Than Aung** introduces mountain agriculture in Myanmar and the importance of using the nation's ecosystem service to develop diversified value-added products to increase food security and boost the rural population's income. The mountain regions of Myanmar are found in five states namely Kachin, Kayah, Kayin, Chin and Shan. This region

has a population of about 6.5 million, with the majority living in the Shan State. There are 118 ethnic groups in the mountain region. Most farmers cultivate a wide range of rainfed tree crops and horticulture products along with rice, maize and pulses. Sadly, according to the Myanmar Poverty and Living Condition Survey (MPLCS) 2017 conducted by the World Bank, poverty rates in mountain regions were higher than national poverty rate. Human resource development and economic reform implementations are also insufficient in Myanmar's mountain region.

Tackling poverty and food insecurity in Myanmar means realizing the huge potential of mountain regions when it comes agricultural diversification and sustainable intensification. This means diversifying crops and moving from staple production to systems that mix crops with Future Smart Foods and shifting from monoculture to diversified and integrated farming systems, animal production and grazing systems, conservation agriculture, etc. Myanmar government has taken on the global GAP and ASEAN GAP initiative to provide protocols and guidelines for some of these unique products in mountains, for instance, the GAP farming and certification are in place for mango, avocado, coffee, tea and sesame in both Shan and Kayah states.

The vision for Myanmar agricultural development in 2030 is to have “an inclusive, competitive, food and nutrition secure and sustainable agricultural system that contributes to the socio-economic wellbeing of farmers and rural people and the further development of the national economy”. Mountain agriculture is going to be a vital part of the country's farming systems and will require special attention and innovative intervention if Myanmar is to reach its SDG2. Agriculture in Myanmar has changed greatly over recent years, moving from subsistence to commercial farming in some mountain areas, where accessibility and market facilities have improved. But most areas still rely on traditional farming practices for their livelihood. Further economic opportunities certainly exist as most of the mountain region is located on the strategic Asian highway network. Factors such as good communications, transportation and trade policy and the future of AESAN +3 will further affect farming, so there needs to be a drive to ensure that there are no undesirable impacts on the environment or overuse of resources.

Although Myanmar has some success stories in terms of mountain agriculture, many challenges and constraints remain. There needs to be greater awareness about the role and importance of mountain agriculture among public and all stakeholders. Systematic survey, assessments, plans, programmes, projects, action plans

and activities need to be formulated in conjunction with international communities, institutions and development partners, based on the framework of Myanmar Agricultural Development Strategies. To embark on this economic opportunity, Myanmar needs to prepare for the future of mountain agriculture and actively participate with international institutions and entities.

Chapter 14 Nepal, by **Rabindra Subedi** and **Manoj Kumar Yadav** shows that Nepal's Agriculture Development Strategy and the Prime Ministers Agriculture Modernization Plan are promising efforts to revitalize food insecure and poverty stricken mountain areas of Nepal through improved production and processing of future smart foods such as finger millet, buckwheat, fruits (e.g. apple, walnut, almond, and peach), vegetables (e.g. cabbage, cauliflower, carrot, and radish) and medicinal and aromatic plants.

Mountainous regions comprise more than 75 percent of the country and host a large but decreasing part of the population. Migration rates to urban areas, the flat and economically dynamic Terai region or other countries are increasing as a response to high poverty and levels of food insecurity levels in these areas as well as the insufficient infrastructural connectivity to the wider economy. In response to these trends the Government of Nepal is investing in targeted efforts to support agriculture-based livelihoods through a range of initiatives.

These initiatives address multiple constraints including establishing more decentralized food processing centres to provide timely market information and value addition in the mountain regions, promoting conservation agriculture to combat soil erosion and fertility loss, and improving general institutional and governance frameworks to support all of the population in establishing mountain agriculture based livelihoods. For example, the Prime Minister's Agriculture Modernization Plan declared crop specific development zones in more than 10 mountain district covering more than 500 ha.

The authors conclude that Nepal has initiated ambitious policies to achieve the Zero Hunger target and reach national food self-sufficiency. Their success will depend on continuous efforts to follow through with these ambitions through cooperation and coordination between all three levels of the Government of Nepal.

Chapter 15 Pakistan, by **Umar Farooq** and **Abdul Wahid Jasra** raises the importance of developing mountain agriculture in Pakistan and realizing the goal of “capitalizing the potential of mountain

agro-ecological zones” in Pakistan’s National Food Security Policy. In Pakistan, more than three-fifths of the total geographical area consists of mountains and rangelands that accommodate more than 50 million people. Most of the rangelands are degraded due to increasing pressure from human and livestock populations coupled with frequent droughts. The fragile mountain ecosystems suffer from degradation of vegetative cover, deterioration of soil, and reduced livestock productivity, which has further impoverished pastoral communities. However, the contribution of mountainous regions and rangelands to livestock production and high-value agricultural commodities in Pakistan cannot be ignored.

The contribution of mountainous regions to the production of high-value agricultural commodities in Pakistan cannot be ignored. These high-value agricultural commodities, i.e. fruits, vegetables, nuts and animal-based products, can be harnessed by adopting cluster-based value chain approach. However, there is a lack of efficient marketing links, market information and infrastructure required for cluster-based value chain development. Institutional support is available for mountain communities, but most of these institutions operate in isolation or are confined to small pockets that are inaccessible to most. Provincial rural support programmes, which endeavour to connect with mountain farmers, have not had significant impact. In order to rejuvenate and improve farming in mountainous areas, a multi-dimensional approach with institutional collaboration is needed.

In Pakistan, sustainable development of mountainous agriculture requires a long-term investment in a comprehensive and integrated approach involving policy, socio-economic and institutional aspects, as well as governance, natural resource management and crop–livestock improvement. At the same time, it is important to holistically address the environmental, economic, social, cultural, and political issues to ensure the sustainable development of mountain agriculture. Several suggestions have been put forward to address these aspects for policy planners, development practitioners, R&D organizations, civil society organizations, and social networks working in and for these areas.

Chapter 16 Viet Nam, by **Luu Ngoc Quyen, Le Huu Huan, Nguyen Thi Thanh Hai and Le Khai Hoan** explains how Viet Nam develops its mountainous regions and the Northern midland, the core region for socio-ecosystem diversity and accounts for almost 30 percent of the country. Around 85 percent of the area has sloping land

with many high mountain ranges integrated with valleys, from the highest mountain (Fansipan at 3 142 m) to the Hoa Binh Valley (20 to 30 m above sea level). This topography creates diverse climates with forest vegetation and crops adapted to different elevations. In terms of mountain population, it is also a highly-diversified region, including 30 ethnic groups with their own cultural characteristics and farming practices. Interestingly, the Northern Midland and mountainous region have experienced significantly faster GDP growth than the country overall. This can be explained by the country’s policy attention to these regions, as well as the unique benefits that mountain agriculture can bring to Viet Nam’s economic development and food security.

The diversity of topography, slope, climate and farming practices in the mountainous areas supports a range of farming systems, which can be grouped by slope and elevation. Food crops such as rice, maize and cassava are important for food security. However, the main niche product is tea. In particular, high altitude areas with a suitable chilling temperature are very good for high-quality Shan tea varieties. Fruit trees also have been increasingly used to take advantage of the diverse natural conditions, especially temperate fruit trees that can generate significant income to the local farmers. More importantly, the large forest areas in the mountainous regions provide sustainable exploitation of the forest using a series of agroforestry models. Conservation agriculture, such as mulching, minimum tillage and intercropping with legumes, are other options for protecting the environment and controlling soil erosion. Such systems will need crops adapted to and suitable for the local conditions that could also contribute to a more nutritious diet, e.g. FSF.

The Viet Nam government has explored different options to manage these challenges and provided value-added measures and activities for mountain specialty products. Models of cooperative chain organization associated with processing and consumption have been beneficial for the region. Typically, enterprises and production households are linked through purchase contracts. In short, the Northern Midland and Mountainous region of Viet Nam plays an important role in national security and environmental protection. Socio-economic development in the region promotes natural resource conservation and the sustainable development of Viet Nam. To achieve Zero Hunger in time, the region needs further support to target market-driven agricultural production, build links between producers and enterprises, develop value chains for mountain specialty products, integrate agriculture with tourism, and create jobs.



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Part IV Conclusions, recommendations and the way forward

Chapter 17 Conclusions, recommendations and the way forward for the sustainable development of mountain agriculture to enhance food security and nutrition, by Mahmoud El Solh, Kadambot H.M. Siddique and Xuan Li presents conclusions of this publication, that includes the recommendations, mountain agriculture's implications for food security and nutrition governance and the way forward.

Recommendations

To address the various challenges facing mountain ecosystems and agriculture, the International Workshop and Regional Expert Consultation event offered a set of policy and programming recommendations for the sustainable development of mountain agriculture to enhance food security and nutrition governance in Asia and contribute to the Zero Hunger initiative. The Workshop and Regional Expert Consultation event offered various approaches/modalities for the way forward for sustainable mountain agriculture development to enhance food security, nutrition governance, and improve livelihoods in the region. This will contribute to the eradication of poverty and hunger, which are global and regional priorities as specified in SDG 1 and SDG 2. It is, therefore, an essential component of the FAO Regional Initiative on Zero Hunger, based on country needs, regional priorities, and all Strategic Programmes. It is important to fulfill the strong desire of countries for knowledge sharing and lessons learned at the regional level to promote

sustainable mountain agriculture in practice for enhancing food security and nutrition in mountain areas to contribute to Zero Hunger and poverty reduction.

The Workshop and the Expert Consultation concluded their deliberations with the following recommendations that need to be implemented at the national and regional level to contribute to the sustainable development of mountain ecosystems and agriculture (Figure ES.5).

1 Policy, socioeconomic and institutional support

The Workshop participants emphasized the importance of developing an enabling policy environment by considering the socioeconomic conditions of mountain people, the challenges facing both mountain ecosystems and agriculture, and the institutional support required for its sustainable development. The following are specific recommendations for consideration and implementation by countries to develop an enabling policy environment and institutional support:

- ◆ Develop and implement policies, strategies and programmes to address challenges, including the socioeconomic and ecosystem-based challenges facing different farming systems and zones of sustainable mountain agriculture development.
 - ◆ Increase attention to risk management and develop policies for prevention, mitigation and relief to cope with natural disasters.
 - ◆ Strengthen existing and establish new national institutions to provide public services, including extension and microcredit to support the development of sustainable mountain agriculture.
 - ◆ Involve representatives of mountain communities in decision-making, policy development and implementation as well as in initiatives that support the development of sustainable mountain agriculture.
 - ◆ Increase the enabling environment for land tenure to consolidate land holdings to ensure investment in long-term appropriate land management. Attention needs to be paid to developing farmers' cooperatives to transfer subsistence agriculture to commercial agriculture for agricultural productivity and income.
 - ◆ Develop infrastructure in mountain areas to support agricultural development and improve.
 - ◆ Increase the levels of investment and financial support for the sustainable development of mountain agriculture at national, regional and international levels.
 - ◆ Increase the resilience of mountain farmers and small agro-industrial enterprises by linking them with markets and providing subsidies to add value to mountain products, especially FSF as well as other non-food products, to diversify the incomes of mountain communities, particularly the incomes of women.
 - ◆ Establish a mountain agriculture fund and funding mechanism for both replenishment and support of agricultural services, activities, and value-added products in mountainous areas.
- ◆ Promote the conservation and sustainable use of natural resources of regional and global importance which are also important to mountainous areas: natural resources, water, biodiversity, soil, natural pastures and forests.
 - ◆ Ensure the adaptation and mitigation of measures to cope with natural hazards as a result of climate change and their pressure on natural resources.
 - ◆ Prevent land degradation and build up soil fertility through using different types of terracing for efficient farming. Planting along contour lines for better water catchment and the reduction of erosion.
 - ◆ Diversify cropping systems (including legumes), use mixed and intercropping techniques.
 - ◆ Promote conservation agriculture, zero tillage and crop rotation.
 - ◆ Conserve water resources and develop rainwater harvesting through both macro- and micro – water catchments to conserve water in soil and use irrigation to mitigate and cope with long periods of drought.
 - ◆ Promote environmentally friendly and ecological practices including biofertilizers and biopesticides to reduce pollution.
 - ◆ Halt and even reverse the reduction of biodiversity and prevent excessive grazing of livestock as well as emphasize the sustainable use of biodiversity.
 - ◆ Promote the agroforestry landscape model by growing forage shrubs that reduce the pressure of grazing on rangelands and natural pastures.

2 Natural resource management

The Workshop participants emphasized the importance of halting and reversing the degradation and unsustainable use of natural resources including water, soil and biodiversity in mountain ecosystems. The following recommendations need to be considered and implemented in this regard:

3 Crop and livestock improvement and integration

The improvement of crops and livestock production is a precondition for enhancing food production and, ultimately, food security and nutrition. The following recommendations need to be considered by policymakers, researchers, extension workers, farmers and producers involved in mountain ecosystems and agriculture:

- ◆ Ensure the development of integrated livestock/crop/rangeland farming systems for effective utilization of natural resources.
- ◆ Develop improved crop varieties adapted to the diverse mountain environments and climate change, including NUS that have great potential as commercial FSF.

- ◆ Promote the cultivation of traditional crop varieties such as FSF and highlight the crucial role of mountain people as custodians of these varieties.
- ◆ Establish livestock community breeding with herders and pastoralists whereby unproductive animals are culled and productive animals are retained to improve livestock populations and herds.
- ◆ Diversify agriculture production and encourage the production of high-value crops, including fruit trees, vegetable and ornamentals as well as value-added products in both crop and livestock production to improve nutrition, income and livelihoods.
- ◆ Promote protected agriculture (mulch, row covers, shade structures, greenhouses, etc.) to intensify the production of high-value crops and increase water use and production efficiencies per unit area in mountain agriculture.
- ◆ Develop and support capacity building (mountain agriculture curriculum and web-based technology in relevant universities) and extension targeting different stakeholders, including farmers' programmes to promote the sustainable development of mountain agriculture.
- ◆ Establish farmer and pastoralist field schools and women empowerment programmes to transfer/exchange technologies and skills to address the challenges facing these important stakeholders.
- ◆ Develop and implement communication programmes and audiovisual aids to promote advanced technologies and knowledge on the development of sustainable mountain agriculture.
- ◆ Make use of International Mountain Day on 11 December to organize events and workshops to promote the sustainable development of mountain agriculture.

4 Research, technology transfer and capacity development

The Workshop participants emphasized the critical importance of making improved technologies and technical know-how available to mountain farmers and producers to bridge the gap between current low productivity and its full potential. This is feasible through the strengthening of specialized well-targeted research in mountain agriculture and the extension of efficient technology transfer to enhance the capacity development of human resources and institutions. The following recommendations address this area:

- ◆ Increase the long-term investment of research programmes in national research institutions and universities to enhance capacity and address the specific challenges facing the sustainable development of mountain agriculture.
- ◆ Develop and modernize extension institutions that specialize in transfer technologies and technical know-how to mountain farmers and agriculture producers through efficient approaches and make use of the tools and facilities already developed through the revolution in information technology, such audiovisual aids (e.g. TV programmes) and mobile phones.

5 Regional and international cooperation

The challenges and problems facing mountain ecosystems and agriculture are often complex, transboundary and difficult to resolve by a single country or institution. A good example is the challenges and problems of transboundary mountain ecosystems and river basins that originate from mountain areas. Therefore, intercountry regional cooperation should be established in areas of common interest, and the following recommendations need to be implemented at the regional or sub-regional level:

- ◆ Strengthen and develop South–South cooperation at the regional level in countries where mountain ecosystems and agriculture constitute a substantial part of the country's agro-ecologies. This involves national research and development in institutions and universities interested in mountain ecosystems and agriculture.
- ◆ Strengthen international cooperation with the United Nations, regional and international cooperation, particularly with FAO, Mountain Partnership, ICIMOD, CGIAR and other relevant institutions
- ◆ Strengthen Mountain Partnership, considering it is the only United Nations voluntary alliance of partners dedicated to improve the lives of mountain people and protect the world's mountain environments as well as increase public–private sector attention, commitment, engagement and investment in the development of sustainable mountain agriculture.



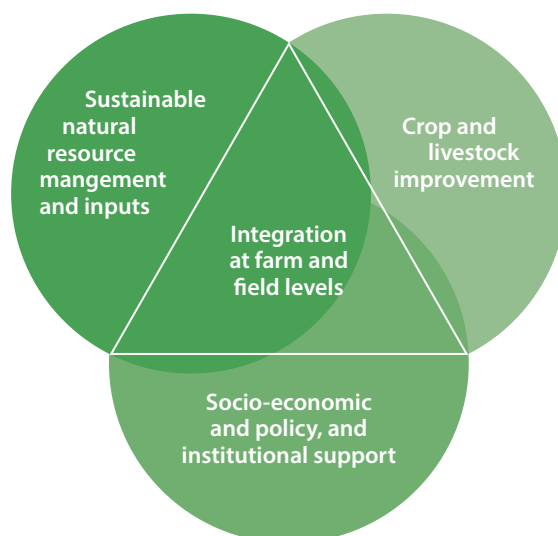
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Implications for food security and nutrition governance

The sustainable development of mountain ecosystems and agriculture is critical for improving food security and livelihoods in vulnerable mountain communities and protecting mountain natural resources, namely water, soil and biodiversity. These natural resources are also important for food security and improving the livelihoods of people living in the surrounding lowlands. Considering the implications to both upstream and downstream populations, at least one billion people are affected by the sustainable development of mountain ecosystems and agriculture.

Mountain people make use of the variation in climates at different altitudes, with different exposures to sunlight from season to season (FAO, 2011). Traditional land-use systems for agricultural production make use of climate variations through sophisticated techniques. Mountain areas have diverse agro-ecologies and as a result, mountain agriculture has different production systems for farming and natural pastures, including 1) pastoral, 2) agro-pastoral systems (both are important to livestock production), 3) rainfed and 4) irrigated production systems and 5) forestry and agroforestry. Both rainfed and irrigated production systems are important for field crops such as rice, wheat and corn, and horticultural

Figure ES.5 An integrated approach for the sustainable development of mountain agriculture



Source: El Solh, 2014

crops including fruit trees and vegetables. The production of livestock, field and horticultural crops are the basis for food security and nutrition.

Mountain areas have many NUS that may be important Future Smart Foods if special attention is given to their nutritional value and adaptation to harsh environments and variable climatic conditions. It is important to assess the nutritional value and adaptation to prevailing NUS in the traditional mountain communities. Furthermore, nutritional value assessments will shed light on their potential to become important commercial crops at national, regional and global levels. A good example is quinoa, which originated in the traditional communities of the Andes Mountains in Latin America that has become a globally important food because of its high nutritional value.

The way forward

The policy, technical, and regional and international cooperation recommendations presented above should be adopted and implemented by national authorities and specialized regional, international and United Nations organizations (where FAO can play an important coordinating role). The implementation of these recommendations will contribute greatly to healthy mountain ecosystems and utilize the full potential of mountain agriculture. This will not only contribute to global food and nutrition security but also ensure the continued services and resources that contribute 70 percent of freshwater resources and various sources of renewable energy to the world community.

Both water and energy are critical to the water–energy–food nexus essential for food and nutritional security, environmental sustainability and poverty reduction.

The sustainable development of mountain agriculture requires the leadership from the government to place mountain agriculture in the centre of national and sub-national policies related to Zero Hunger and poverty reduction, and long-term investment in a holistic and integrated approach involving policy, socioeconomic, institutional aspects, natural resource management, and crop and livestock improvement. The investment should be followed by integration among all these factors in farmers' fields to achieve synergy as a result of the integration of these three important themes 1) sustainable natural resource management and inputs; 2) crop and livestock improvement, and 3) socioeconomic, enabling policies, and institutional support.

Negligence of mountain areas, where about one billion people reside, has contributed greatly to global poverty, food insecurity and malnutrition. It is essential that governments develop specialized institutions at the national level to address the multilateral challenges facing the sustainable development of mountain ecosystems and agriculture. These institutions need to implement the policy, technical and regional cooperation recommendations to improve livelihoods, reduce poverty and enhance food and nutritional security.



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Part I

SETTING THE SCENE



1 Introduction, mountain agriculture: opportunities for harnessing Zero Hunger in Asia

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1.1 Context

Eradication of hunger and all forms of malnutrition is one of the main Sustainable Development Goals (SDGs) and a core mandate of the Zero Hunger Goal (SDG2). The Asia-Pacific Region is no exception. While the 1st Millennium Development Goals (MDG1) have been mostly achieved, the region is home to 490 million people living with chronic hunger, including some 62 percent of the world's undernourished people in 2018 (FAO, 2018a). The problem of stunting prevails with levels of more than 40 percent in many Asia countries. Micronutrient deficiencies remain a major problem in Asia, especially in mountain regions.

The world currently faces a multitude of global challenges: hunger and malnutrition, climate change, environmental degradation, water scarcity and desertification, loss of biodiversity, population growth, migration and so on. These challenges disproportionately and more severely affect mountain regions and their inhabitants, particularly in developing countries (FAO, 2011). There are various reasons for this, including harsh climatic conditions, weak infrastructure, poor market access, and lost economic opportunities, due to the inaccessibility, fragility and seasonality of mountain areas.

Why is mountain agriculture so important from a Zero Hunger perspective? Well, first of all, mountains are home to one-tenth of the world's population. Around 40 percent of mountain populations reside in developing and transition countries and about 300 million mountain people are food insecure, with half suffering from chronic hunger (Dach *et al.*, 2013). While the global average of food insecure people is one in eight, (39 percent of mountain populations in

developing countries were food insecure in 2012, a 30 percent increase in the number of vulnerable mountain people since 2000), one in two food-insecure people live in rural mountain areas (FAO, 2015a). This is no exception in the Asia region. Being disadvantaged and living in remote areas, mountain populations in Asia are particularly vulnerable to food insecurity and malnutrition. (FAO, 2015a). According to the FAO, more than 192 million mountain people in Asia were considered vulnerable to food insecurity in 2012, an increase of 26 percent from 2000 (Table 1.1), and these people were mainly living in Central, Southern and Western Asia, where the increase in the number of vulnerable people exceeded 50 percent (FAO, 2015a). According to the study, the proportion of vulnerable people among mountain populations in Asia grew from 35 percent to 41 percent, more or less equally spread among the five sub-regions. (FAO, 2015a). So, how to reverse the growing trend of food insecurity in mountains and feed mountain populations is clearly an urgent issue.

Secondly, it has to be remembered that mountains cover 22 percent (32 million km²) of the world's surface and mountain ranges make up a significant part of the Asian landmass with over one third of the world's mountains (35 percent) found there (FAO, 2015a). In Asia, most countries are mountainous or have mountainous regions. For example, in Lao PDR, mountain and upland areas make up 89 percent (210 000 km²) of the country's land area (FAO, 2000). In Bhutan, nearly all the land is mountainous, with the exception of the foothills in the south where there are gentle plains. (Britannica, n.d.). In Nepal, mountain areas occupy 35 percent of the total land area whereas almost 61 percent of the total land area of Pakistan is mountainous or made up of

Table 1.1 Distribution of vulnerable rural mountain populations living in developing countries of the Asian region in 2012

Subregion	Number of vulnerable mountain people ('000)		Percentage change 2000–2012 (%)	Distribution of vulnerable mountain people (%)		Vulnerable mountain people out of total mountain people (%)	
	2000	2012		2000	2012	2000	2012
Central Asia	2 023	3 136	55	1.3	1.6	28	34
Eastern Asia	84 449	93 595	11	55	49	35	42
Southeastern Asia	18 257	21 532	18	12	11	36	41
Southern Asia	35 181	54 150	54	23	28	38	42
Western Asia	12 655	20 364	61	8	11	28	34
Total	152 564	192 778	26	100	100	35	41

Source: FAO, 2015a

rangelands that support a population of more than 50 million people (Pakistan Bureau of Statistics, 2010). As mountains occupy such a huge amount of land surface without the possibility of people being relocated in most Asian countries, developing an efficient systems of mountain agriculture is vital.

Thirdly, the livelihood of large segments of mountain populations depends heavily on mountain agriculture. For instance, in the northern mountain regions of Viet Nam and the Uttar Pradesh region of the Central Himalaya in India, more than 90 percent of the workforce is involved in agriculture. (Jenny and Egal, 2002) Notably, the poverty rate in the Northern Midland and Mountainous region of the northern Viet Nam is high and was three times higher than the country's average in 2016. Three provinces out of 15 northern provinces in this region have extremely high rates of poverty: Dien Bien (44.8 percent), Son La (31.9 percent), and Ha Giang (38.8 percent) (MOLISA, 2017). This means that a focus on ensuring mountain agriculture is used as a tool to improve mountain people's livelihoods is essential.

So, from a Zero Hunger perspective, countries have no option but to develop mountain agriculture to ensure that “no one is left behind”. In the context of SDGs, in view of UN Decade for Family Farming 2019–2028, the UN Decade of Action on Nutrition 2016–2025, and the UN Decade on Ecosystem Restoration 2021–2030, strengthening mountain agriculture is considered a priority towards Zero Hunger and poverty reduction in Asian countries.

How could mountain agriculture be developed? While mountain ecosystems are fragile and subject to natural drivers of change, mountains represent unique

opportunities for agricultural development, especially through the production of mountain speciality products. This is because mountains host approximately one-quarter of all terrestrial biodiversity and nearly half of the world's biodiversity hotspots. Mountain agriculture has huge potential for enhancing food security and nutrition as well as dietary and production diversity based on the abundant agrobiodiversity in mountain ecosystems. Strengthening and enhancing traditional farming systems will increase the resilience of small-scale farmers. Mountains are often also home to diverse cultures and stunning scenery that can attract tourists – another potential revenue stream.

This publication, *Mountain Agriculture: Opportunities for harnessing Zero Hunger in Asia* focuses on the opportunities that mountain agriculture offers to achieve Zero Hunger and improve the livelihoods of mountain populations, and on removing constraints that hinder the development of sustainable mountain agriculture. As an entry point, this publication emphasizes the opportunities that mountain biodiversity offers for Zero Hunger. Promoting Future Smart Food (i.e. Neglected and Underutilized species that are nutrition-dense, climate-resilient, economically-viable and locally available or adaptable) with mountain specialty is considered a good option (FAO, 2018).

Against this background, the FAO and its partners regard it timely to focus on mountain agriculture as a theme for addressing Zero Hunger and poverty reduction. A series of activities have been initiated, including an International Workshop and Regional Expert Consultation on Strengthening Mountain Agriculture Development and Food Security and Nutrition Governance (hereafter, “the Mountain Consultation”), to consider the above-mentioned key issues in

mountain areas in depth. This publication presents a regional overview on mountain agriculture development based on thematic analysis and national studies.

1.2 Why mountain agriculture deserves special attention

1.2.1 About mountain agriculture

Mountain agriculture is broadly defined as agricultural activities on land surfaces at higher elevations including cropping, horticulture, forestry, animal husbandry, water harvesting, and a variety of conservation practices (Jodha, 2009).

Mountain agriculture is an essential resource for supplying food to the population, producing typical nutritious and high-quality products, preserving and maintaining the cultural landscape, including tourism (ecosystem services), and protecting the soil against erosion, avalanches and floods (Alpine Convention, 2017). The share of food production in the mountainous areas of each country strongly depends on the proportion of mountain land relative to the total land area, the area of land devoted to agricultural and food production, the availability of water resources, and the products grown, and productivity. This is because some specific products are more widespread than others in mountain areas (Alpine Convention, 2017). Because of its constraints (topography, difficult climatic and water conditions, remoteness etc.), mountain agriculture plays a complementary, but often important, role in country's agricultural sector.

Mountains have distinct features for agriculture development that include steep, sloping sides and sharp or slightly rounded ridges and peaks. Cultivation areas are often small, dispersed at different altitudes, with many different climates and with limited use for mechanization. However, there are high plateau areas that are considerably flat across large areas but high with elevations like the Tibet plateau which is more than 2 000 m in elevation. Accessibility is a key issue in mountain agriculture. Prevailing farming systems in mountain areas include family farms and smallholder agriculture, forestry and animal husbandry based on natural pastures.

Genetic diversity in agriculture is an important prerequisite for food security. (FAO, 1997) Mountains hold much agro-genetic diversity, offering huge potential for local nutritious and diversified food. Consequently, mountain agriculture offers opportunities for high crop diversification, integrated

forests and husbandry activities, with a low carbon footprint. It should be noted, however, that many mountain farmers have abandoned their traditional and diversified agricultural systems, and increasingly rely on a single cash crop for their livelihoods (FAO, 2011). Traditional knowledge on local foods and agricultural practices has been eroding and agricultural diversity has been declining.

1.2.2 Agro-climatic distinctions between mountains and plains

According to FAO, it is estimated that around 45 percent of the world's mountain areas are not, or only marginally, suitable for growing crops, raising livestock or carrying out forestry activities (FAO, 2015b). Mountain agriculture is impacted by highly differentiated climatic conditions due to altitude, large daily and seasonal temperature fluctuations and changes in aspect and exposure within short distances. (FAO, 2015b). Consequently, crop growth is slower due to the lower temperatures at high altitudes and, accordingly, farmers can only harvest one crop per year. (FAO, 2015b). The particular agro-climatic features of mountain environments and their impacts on mountain agriculture are listed below:

Climate: the climatic differences between mountains and plains are driven by temperature and precipitation. The temperature decreases with increasing elevation (Barrow, 2013). In terms of precipitation, mountains tend to have wetter climates than the surrounding lowlands, due mainly to orographic effects. Consequently, mountains receive in general more precipitation than low-lying areas (Barrow, 2013). However, mountain precipitation is not equally distributed in areas with the same elevation due to differentiated topography. Depending on the dominant air circulation patterns in many mountain areas, a significant proportion of precipitation falls on the windward side of mountains whereas the leeward side lies in the "rain shadow". A typical example is the Himalayan range: whereas the southern slopes receive ample monsoon rains, the northern slopes are in the rain shadow resulting in arid or semi-arid conditions (Ladakh, Mustang, Tibetan Plateau), (Barrow, 2013).

Vegetation and biodiversity: The differentiated topography and the diversity in climatic conditions result in a large variety of ecosystems and rich biodiversity: in different elevations different plants and animals are available. Ecosystems can differ over short distances due to the changes in altitude and temperature along a mountain slope. Ecosystems can also be very different at the same elevations depending

on windward and leeward side. In terms of vegetation, the growth depends on altitude, precipitation and temperature as well as on the climate zone in which the mountain system is located. The foothills may be characterized by broadleaved forests. With increasing altitudes the vegetation may change to needle leaf trees like spruce and pines. The trees may gradually thin out and disappear with further increasing altitude and decreasing temperature. Above the timberline the vegetation is characterized by sparse grasses and low-growing alpine flowers which can withstand the harsh conditions. If the mountain range is high enough, e.g. the Hindu Kush Himalayas, even this vegetation disappears and what remains is bare rock and, eventually, snow and ice. Because of the rapid changes in altitude and temperature along a mountain gradient, multiple ecological zones are “stacked” upon one another sometimes ranging from dense tropical jungles to glacial ice within a few kilometers (Barrow, 2013).

Soils: Generally speaking, mountain soils are considered as poorly developed, skeletal, shallow, acidic and relatively infertile (FAO, 2015b). As elevation increases, mountain soils normally become shallow and less fertile because of soil erosion and low temperatures which limit the biological activities. Mountain soils are often degraded due to leaching of nutrients, erosion by water on steep slopes and erosion by wind and water in exposed areas. As a result, mountain soils are often less productive than soils in plain areas.

Climate change and disasters: Mountain areas are disproportionately affected by climate change and natural disasters. There is recent scientific evidence that the temperature increase in the Himalayan area is significantly higher than the global average. Melting glaciers are the most well-known impact of climate change on mountain ecosystems. An increase in natural hazards as a result of upwards movement of permafrost, shifting of vegetation zones, pressures on specialized and poorly buffered agricultural systems are additional impacts of climate change in mountain areas.

What does all this mean for mountain agriculture?

The specific agroclimatic features of mountain environments presented above pose specific challenges and also offer opportunities for mountain agriculture as compared to agriculture in the plain (Table 1.2). So how do the agroclimatic features of mountain affect agriculture in mountainous regions?

- ◆ In many mountain regions of Asia, agriculture is practised through agro-sylvo-pastoral and family farming systems. Due to the generally small plot sizes, most mountain farmers practice conservation farming with very limited mechanization and low or zero tillage. Terracing is widely practiced in steep mountainous areas, which is an effective approach to limiting erosion and land degradation. This activity requires substantial knowledge about soil types and how to manage them on steep slopes, keeping in mind the high vulnerability of the soils to erosion (FAO, 2015b). Slopes with steep and differing elevations often make the soil shallow, poor in micronutrients, limited and difficult to cultivate and unsuitable for mass agricultural production.
- ◆ The differentiated topography in terms of altitude, slope and exposure in mountains provides opportunities to produce high value and niche products on slopes and terraces based on their light and moisture requirements. The direction that a slope faces determines when crops are exposed to sunshine during the day. For example, slopes facing northeast in Nepal have successful citrus cultivation due to the availability of early morning sunshine followed by shade at noon that helps conserve soil moisture, whereas plots facing southwest at the same elevation are devoid of citrus trees (Shrestha *et al.*, 2001). Since soil types differ with the land topography, a variety of crops that require different soil, climate, and topography conditions can be produced on hills and terraces (Chapagain and Raizada, 2017).
- ◆ The weather and soil conditions in mountain areas shorten the growing season, labour costs are higher and the topography makes the use of conventional machinery more difficult, meaning further expenditure for specialised tools is often necessary (Mambro, 2015).
- ◆ Farms in mountains tend to be small-scale, remote from logistic centres and at high risk of abandonment, which is considered as disadvantageous (Mambro, 2015). Furthermore, distance from roads, poor infrastructure and marginalization render local processing, value chain development and access to markets more difficult.

Table 1.2 General agro-climatic features between mountain agriculture and plain agriculture

Biophysical conditions	Mountain agriculture	Plain agriculture
Altitude	High	Low
Slopes	Steep and high Plateau flat areas	Flat
Soil	In general poor, infertile, skeletal, shallow and acidic with fertile pockets	Fertile
Temperature	Cold	Warm
Rainfall	Reliable	Less reliable
Moisture	More available although 'rain shadow' effect in certain mountain areas based on exposure	Equally distributed in areas with same elevation
Water resources	Fast-flowing rivers, clear	In certain areas slow-flowing rivers, coloured by sediment and organic matter
Land holdings	Small, fragmented and scattered	Small, medium and large
Irrigated land	Limited because of lack of infrastructure	Available in certain areas where irrigation water is available.
Biodiversity	High	Low
Ecosystems	Heterogeneous	Homogeneous



Implications for mountain agriculture under the current situation of lack of support and investment

- ◆ Low productivity
- ◆ Low scale of economy
- ◆ Monocropping restricted
- ◆ Cold-resistance
- ◆ Integrated farming systems
- ◆ Mountain specialty products
- ◆ Off-season fruits production opportunity

- ◆ Although general principles can be applied to mountain products, a more specific value chain approach must be tailored to each single mountain product and for each single country. Mountain products can be mainly categorized as specialty or niche products. They are usually produced on a small-scale basis, considering the limited resources available in those altitudes and the size of the rural communities, compared to low-land environment. The high value of these products compensates for the small volumes commercialized. Considerations regarding fragile mountain ecosystems, the traditional way of life of the people, limited production capacity and distance from the markets for instance may be seen as an obstacle for large scale marketing objectives but, on the other hand, as a safeguard for the sustainability of the socio-economy of the mountain communities. By promoting a set of high value products and services produced by mountain people, the total production system can be intensified and, at the

same time, the risk of degradation of natural resources or food insecurity can be reduced. The more inaccessible, fragile, and marginal a mountain area is, the greater the challenges and risks involved in production are, promoting diversity instead of economies of scale, should be the preferred strategy.

While lowland agriculture receives much more attention than mountain agriculture, due to higher relative productivity and economy of scale, mountains also offer unique and specific opportunities for agriculture owing to their variations in climate, soils, elevations and slopes, which provide for a much larger diversity. Various examples of how mountain specialty products contribute to food security and can resist the competition from low land agriculture products will be elaborated upon in Section 1.3. Mountain agriculture requires special attention and investment to exploit its economic potential and valuable contribution to global food security and nutrition.

Table 1.3 Four main dimensions of food security

1 Physical availability of food	Food availability addresses the “supply side” of food security and is determined by the level of food production, stock levels and net trade.
2 Economic and physical access to food	An adequate supply of food at the national or international level does not in itself guarantee household food security. This is why affordability of food available is an important component of food security.
3 Food utilization	Utilization is commonly understood as the way the body makes the most of the various nutrients in food to ensure balanced nutrition. It matters for the <i>nutritional status</i> of individuals.
4 Stability of the other three dimensions over time	Even if an individual’s food intake is adequate today, they are considered food insecure if they have inadequate access to food on a periodic basis, risking the deterioration of nutritional status and if production or physical availability is reduced to changes in environment and investment.

Source: FAO, 2008

In short, mountain environments offer a highly diversified environment for a variety of diversified agricultural systems. However, promoting these diversified mountain agriculture systems requires improved technologies as well as investment in infrastructure, research and technology transfer to farmers. The potential for mountain agriculture lies in high value specialty or niche products, which have a high market value, in addition to its great potential in contributing to global food security and nutrition provided it receives and well-deserved support in investment in infrastructure and technology transfer for sustainable agriculture development.

1.3 What opportunities does mountain agriculture offer toward Zero Hunger?

Mountain agriculture offers enormous potential for meeting Zero Hunger targets. Food security and nutrition are the core of Zero Hunger (SDG2). According to the definition of food security in The State of Food Insecurity 2001, “food security exists when all people, at all times, have physical, social and economic access to sufficient, safe and nutritious food which meets their dietary needs and food preferences for an active and healthy life” (FAO, 2003). As such, food security encompasses four main dimensions: food availability, food access, food utilization and food stability (Table 1.3). It also stresses the issue of diversity beyond a certain amount of food consumed. For food security objectives to be realized, all four dimensions must be fulfilled simultaneously (FAO, 2008). While mountain agriculture often suffers from inaccessibility, seasonality and fragility, it has comparative advantages with its climatic and ecological specifics and potential to provide sufficient, safe and nutritious food for all, especially inhabitants of

mountainous areas. This section demonstrates how mountain agriculture could contribute to satisfying all four dimensions of food security.

1.3.1 Expand food availability

Mountains have the potential to increase total agriculture production for *sufficient, nutritious and safe* food, as mountain speciality products, based on the magnitude of vast but underdeveloped land areas, a high level of topological diversity, agroclimate specifics of mountain regions, and different growing seasons.

A Increase the availability of sufficient food

Mountain areas have a substantial comparative advantage for a wide range of fruit, nuts, vegetables, livestock and by-products, and other high-value products, most of which are potentially Future Smart Foods (FSF) that could contribute to the improvement of food availability of sufficient, nutritious and safe food and address food shortages. (NUS) are neglected and underutilized species (NUS) that are nutrition-dense, climate-resilient, economically-viable and locally available or adaptable (FAO, 2018). (for more elaboration on FSFs see Chapter 3). For example, mountain and hill regions in Nepal contribute 42 percent of total national vegetable production (MoAD, 2015), which makes a significant contribution to the national production of fruit and vegetables. In terms of contribution, the mountain areas of China (e.g. Yunnan Province) perform much better than mountain areas in the other Hindu Kush Himalayan (HKH) countries (Hussainetal, 2016), (Rasul and Saboor, 2019).

The land topography in mountain areas offers opportunities to grow a variety of high-value crops, horticulture, livestock and forest species, alone or

in combination, on slopes and terraces. This would create an opportunity to adopt site-specific agroforestry systems integrating crops, trees, vegetables, fruits, pastures, and livestock (Chapagain and Raizada, 2017). Diversification of agriculture production contributes to better nutrition, more income to improve livelihoods and increases the resilience of farmers. In Nepal, for example, the principal field crops grown on terraces are maize (*Zea mays* L.) and rice (*Oryza sativa* L.); FSF such as the common bean (*Phaseolus vulgaris* L.), field pea (*Pisum sativum* L.), and wild legumes can be cultivated depending on the season and farmers' interest (Riley *et al.*, 1987; Dach *et al.*, 2013). In Pakistan, the cultivation of horticultural crops in mountain areas is increasing, although of total cultivable land, more than 10 percent was used for fruit production and 9 percent for vegetable cultivation in Gilgit-Baltistan (GB) Province and 22 percent and 3.7 percent, respectively, in Balochistan Province in 2011–12 (Rasul and Hussain, 2015). Balochistan, which occupies the most southeastern portion of the Iranian Plateau and is noted for its extremely dry desert climate, contributes substantially to the national production of apple, apricot, cherry, fig, grapes, peach, pomegranate, plum and almond. Khyber Pakhtunkhwa Province contributes significantly to the national production of apple, fig, loquat, peach, pear, persimmon, plum, and walnut; while the smaller mountain areas of Federally Administered Tribal Areas and GB in the northern dry mountains contribute significantly to the production of apricot, cherry, fig, mulberry, and walnut (Rasul and Hussain, 2015).

Fallow land in mountain areas can be used to contribute to food availability. During the dry season, when most highlands are left fallow after harvesting the main field crops, food availability could be improved by introducing FSF. Such FSF can grow on the moisture remaining from harvests in the rainy season or drip irrigation, combined with integrated farming practices such as intercropping and relayed cropping, which can utilize fallow land for planting forages, along with planting of the main crops and other high-value crops. For instance, India has actively integrated pulses into rice fallow on a large scale. The selection of crops and varieties with different root architecture (i.e. longer and finer roots, more root tips, greater branching angle, and lower shoot:root ratios) and *in situ* moisture conservation practices (e.g. ridging, mulching) may help to minimize irrigation requirements during dry periods (Rasul and Hussain, 2015).

Mountains are an important resource for livestock raising, which plays a pivotal role in the lives of mountain farmers, and provides manure that enhances soil fertility. Nearly 70 percent of mountain land is used for grazing. Livestock not only produces food items such as milk, butter, and meat, but valuable by-products such as wool. The wide range of animal genetic resources in mountains is a valuable foundation for development of the livestock sector. For example, mountain pastoralists in Pakistan have a highly treasured livestock genetic resource pool with special traits bred into animals that ensure they are adapted to the rugged terrain, steep slopes, and poor-quality forage, as well as being disease resistant. Such livestock's productive and reproductive performances relative to body weight are higher than those of advanced breeds (Rasul and Hussain, 2015).

B Increase the availability of nutritious food

Mountains can provide a huge amount of nutritious food. Mountains are rich in biodiversity, which contributes to the provision of nutritious food necessary for healthy and diverse diets. Biodiversity can be measured at three levels: the highest level is food group diversity (e.g. cereals, dark green leafy vegetables and fruits), the next level is within a food group (e.g. mango, banana and apple) and the lowest level is within a species (e.g. types of cultivated apple and unnamed local and wild varieties) (Kennedy *et al.*, 2017). The unique agroclimatic conditions in mountain regions and their different growing seasons allow the mountains to provide diversified food at all levels and so are home to a wide range of nutritious food groups and intragroup diversity with thousands of varieties of fruits, vegetables, fruits, grains, legumes, seeds, nuts, animal breeds, fish, honey, insects and fungi. While they tend to contribute a small amount of caloric energy globally, they play an important role of nutrition security and make an important contribution to dietary diversity. For example, in Viet Nam, wild vegetables contribute 43 percent (Central Highland) of the total weight of vegetables consumed (Kennedy *et al.*, 2017). These species are often higher in micronutrients (vitamins, minerals) and macronutrients (fats and protein) than their more widely cultivated exotic counterparts, and include wild food species such as indigenous fruit trees, indigenous leafy vegetables and wild plant and animal species (Kennedy *et al.*, 2017). These species often qualify as FSF, being NUS that are nutrition-dense (enhance nutrition), climate-resilient (e.g. require low inputs, promote climate change resiliency, environmentally friendly by reducing

runoff and erosion, economically viable (generate income and reduce female drudgery) and locally available or adaptable (FAO, 2018b).

C Increase the availability of safe, organic and healthy food

Mountain agriculture has a comparative advantage for the production of safe and organic products. For instance, in India's Central Himalayan Region, women farmers are knowledgeable in traditional agricultural practices that use no chemical inputs. Organized by agricultural microenterprises, 2 800 women farmers have increased supply and capitalized on the growing demand for organic products. Eighteen different types of traditional crops are marketed in Indian cities, including buckwheat, horse gram and foxtail millet. Recognizing its high quality, a Japanese company has begun purchasing foxtail millet in bulk for the preparation of baby foods (Khalid and Kaushik, 2008).

Mountains have a unique advantage for producing specific medicinal plants. For instance, in South Asian countries, many mountainous plants have medicinal functions, such as the rare White Garcinia fruit, which is found in the forests of southern India, and is used in Ayurvedic medicine to treat severe gastric reflux. In the Pamir Mountains, safflower, purslane, black cumin, sea buckthorn and wild rose, among others, are used to treat common ailments (Kennedy *et al.*, 2017).

1.3.2 Improve food access

Hunger is a consequence not only of food shortage but of inadequate food access. Food access in mountain communities is linked to being able to 1) meet mountain household requirements for food by producing them locally or 2) generate income from mountain products and services such as crop production, livestock production, forestry and tourism to purchase food and other household requirements. Mountain agricultural production sustains the household's own food needs, with any surplus bartered for food or non-food items. An increasing level of monetary income can lead to cash availability for many mountain households and so improve their food access.

A Improve mountain household access to food directly

Mountains have the potential to enhance food access for mountain people directly. Mountain communities are home to some of the poorest people and they rely on subsistence farming. What people eat depends largely on what they grow and raise in the area in which they live. In Pakistan,

almost 61 percent of the geographical area is mountainous and accommodates nearly 40 million people, whose livelihoods and food security depend heavily on the local resource base at all elevations (Rasul and Hussain, 2015). Agriculture, livestock, and horticulture are the main sources of mountain livelihoods, with livestock becoming more important than arable farming at higher elevations (Rasul and Hussain, 2015). In the absence of other means of subsistence, livestock provide the mainstay of more than 75 percent of the rural population (Rasul and Hussain, 2015). While crop growth in mountains is slower at higher altitudes and mountain farmers often rely on only one harvest per year from their land, the rich agro-biodiversity in mountain areas, if properly managed, can result in dietary diversification that contributes to food access. For example, Nepal has prioritized crop diversification and introduced high-yield varieties of Future Smart Food, such as buckwheat, finger millet, foxtail millet, etc. which generates higher yield for mountain households to access to nutritious food.

B Improve access to food by generating income from the sale of mountain products and services indirectly

Mountain agriculture can improve access to food through income generated from planting, harvesting, raising and selling of mountain products and services (such as eco-tourism) indirectly, which enables mountain farmers to buy food they need. For instance, in Bhutan, mountain farmers earned income from planting citrus fruits, especially the mandarin orange, which tops the list of horticultural exports from Bhutan: in 2014/15, more than 25 500 MT of mandarin orange were exported to Bangladesh and over 8 900 MT to India (Molden, 2015). In Nepal, ginger is an important high value commodity which provides notable export opportunity: The country produced 11.5 percent of world's total ginger in 2008, becoming the fourth largest producer (Molden, 2015). In Bangladesh, popular high value mountain products include *jhum* products like foxtail millet, black and brown sticky rice, colocacia, cucurbits, cotton, beans and other legumes; bamboo and cane products; and other products like cashew nut, coffee, and mushroom (Molden, 2015). Livestock brings good opportunities to earn income through increased livestock productivity and the growing volume of by-products such as pashmina wool. For instance, in Khyber Pakhtunkhwa (KPK), the Ajar pastoralist community (around 7 500 landless households) market small ruminants worth USD 68 million per year. (Rasul and Hussain, 2015). Enhanced and adapted mountain

agriculture systems, such as terraces, can improve incomes and attract eco-tourism. Terraces can grow legumes, vegetables, spices, and flowers to cover unused vertical slopes increasing land productivity and economic returns. In Nepal, growing chayote, pumpkin, and yam on terrace walls can provide up to USD 100 of additional income per household (Chapagain and Raizada, 2017). Rice terraces in China are a good example of a way where communities gain income from eco-tourism. The Hani Rice Terraces in Yuanyang, China, were inscribed on the FAO Globally Important Agricultural Heritage Systems (GIAHS) List in 2010 and on the UNESCO World Heritage List in 2013 which increased the number of tourists and income from tourism with the endorsement of the agricultural heritage systems (Chapagain and Raizada, 2017).

1.3.3 Improve food utilization

Food utilization affects the nutritional status of individuals. Sufficient energy and nutrient intake by individuals result from good care and feeding practices, food preparation, dietary diversity and intrahousehold food distribution. Combined with good biological utilization of food consumed, this determines the *nutritional status* of individuals (FAO, 2008). Food biodiversity and the diversity of plants, animals and other organisms used for food, both cultivated and from the wild, is a critical element in response to malnutrition (Kennedy *et al.*, 2017). Mountain areas provide huge food biodiversity that results in both production and dietary diversity to further contribute to meeting nutritional requirements. Special and diversified mountain agroclimatic conditions allow mountains to produce a wide varieties of food products, e.g. fruits, vegetables, chestnuts, pine nuts, which provide energy, protein and micronutrients to diversify diets and offer nutritional improvement. It should be highlighted that the nutrient content between different species, or different varieties or breeds of the same species, can vary a thousand-fold (Kennedy *et al.*, 2017). Similar to the medicinal value of specific plants, the nutritional value of food is associated with the area where the crop was grown: from the climatic conditions, the soil type, processing methods, etc.

Institutional and technical support can help mountain farmers to provide nutritious products which will contribute to changing dietary patterns and improve the nutritional status of individuals. Take vegetables – an important source of micronutrients – as an example. Mountains are suitable for growing a variety of vegetables including turnips, potatoes, cabbages, cauliflowers, tomatoes and carrots, depending on the

specific location. For instance, in Ladakh, Northern India, the Agriculture Department has subsidized seed purchases to encourage diversification of farmed vegetables. The government has established horticulture programmes to introduce new technologies, such as the construction of greenhouses and storage facilities, including the use of polythene sheeting for greenhouse construction, which can extend the seasonal availability of vegetable products. The new technologies increase the local availability of fresh vegetables, especially during winter months when traditionally the community relies on dried vegetables and stored roots as well as vegetable imports from the lowlands, which are sold at prohibitive prices due to air transportation costs. Many smallholders have started to establish kitchen gardens and grow a limited amount of fresh vegetables to diversify their diet (Dame and Nüsser, 2011). These efforts have led to changing dietary patterns in Ladakh: a comparison of dietary habits showed a significant increase in vegetable consumption, especially during summer months (Dame and Nüsser, 2011).

1.3.4 Improve food stability

Stability refers to the availability, access and utilization of food at all times without risks. Adverse weather conditions, political instability, or economic factors may have an impact on food security status (FAO, 2008). In the off-season, there is often a shortage of many varieties of agricultural products, which results in rising food prices. The seasonal variation of food stability affects the seasonal variation of dietary patterns, which reflects issues of market availability, caloric demands and the time required for food preparation (Dame and Nüsser, 2011). Mountain agriculture offers unique opportunities for filling the seasonal gap. In particular, the special and diversified agrilclimate of high-altitude favours the cultivation of a variety of off-season cultivation such as high-quality vegetables (Sati, 2006) – a product which is in high demand among consumers. For instance, in Himachal Pradesh, off-season vegetable cultivation emerged as a remunerative enterprise for small and marginal farmers. The Himachal Pradesh, Kullu district has become famous for the production of quality off-season vegetables, which take up more than 80 percent of the agricultural area. As a result, the cropping intensity increased by 250 percent, even on the smaller farms. With the provision of farmer training and availability of low-cost mechanical tools, labour costs can be reduced and the provision of off-season agricultural products are more likely (Barah, 2010). The mountain areas of Pakistan have specific climatic conditions conducive to the production of high-quality seed potato, vegetable seeds, off-season vegetables,

and medicinal plants, which can provide food stability as they could potentially meet the whole country's requirement for seed potatoes and vegetable seeds (Rasul and Hussain, 2015)

In summary, mountain agriculture offers huge opportunities and innovative solutions with success stories for Zero Hunger. These are built on the long experience and indigenous knowledge that mountain communities have developed over generations on how to practise agriculture under difficult conditions to tap its full potentials. However, considering the existing obstacles in terms of topography, climate, remoteness, etc, **mountain agriculture requires much more attention in national and sub-national policies in order to bring its potential to full fruition and in order to improve the livelihood situation of mountain communities.**

1.4 International workshop and regional expert consultation on mountain agriculture development and food security and nutrition governance

To facilitate knowledge sharing on mountain agriculture and support countries to identify possible solutions, entry points and policy mechanisms promoting mountain agriculture development towards Zero Hunger and poverty reduction, the FAO Regional Office for Asia and the Pacific and University of International Relations, in collaboration with a number of national and international partners, conducted the Mountain Consultation in Beijing from 30 October to 1 November 2018. Overall, the Mountain Consultation comprised four steps as follows (Figure 1.1):

1 Step 1: Conceptualization

Food security and nutrition in mountains are challenging issues, but paradoxically are often ignored in development policies. While mountains face peculiar challenges when it comes to agriculture, they also offer unique and specific opportunities for agriculture to address Zero Hunger. However, the main constraints and opportunities for farming in mountain regions are at the country level and special attention is required to explore the full potential of mountain agriculture. Against this background, the FAO RAP's Regional Initiative on Zero Hunger (RI-ZH), in consultation with concerned parties at the FAO, both internally and externally, set mountain agriculture as one of priorities for programmatic working area of RI-ZH.

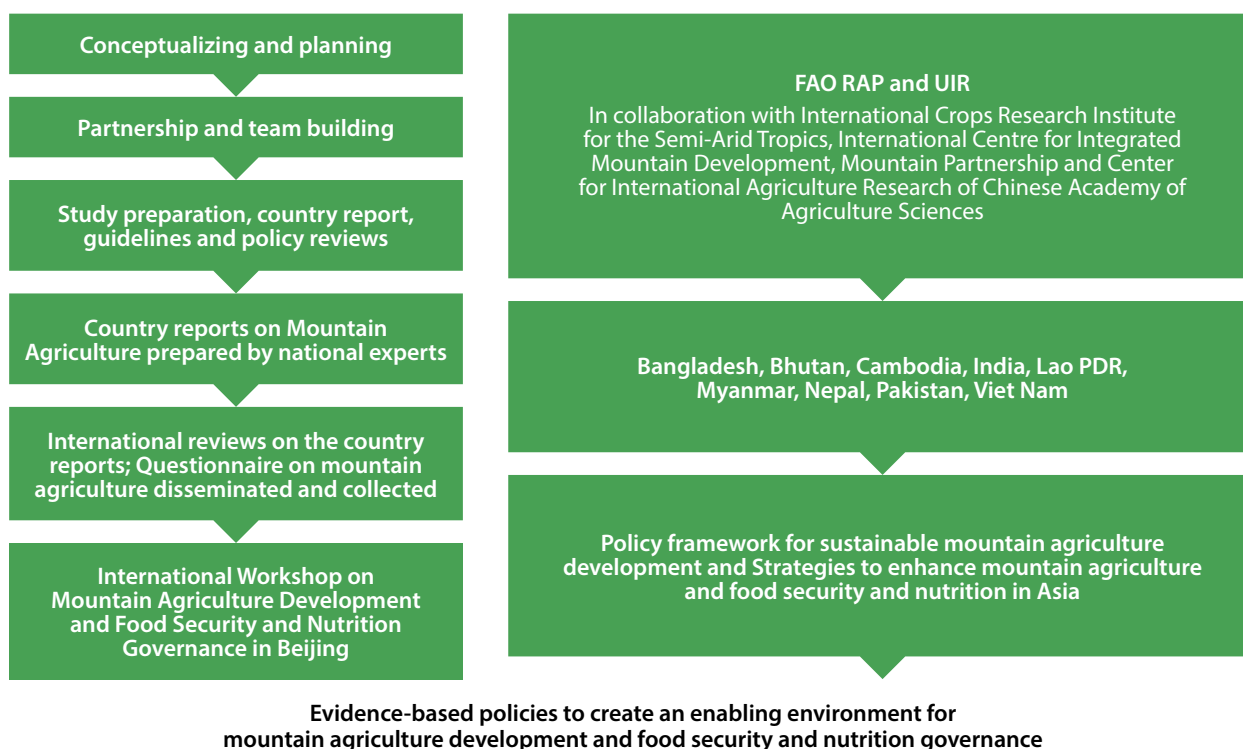
Several questions required assessment: what are the main multi-dimensional challenges that mountain agriculture faces at the country level? What are the major opportunities that mountain agriculture offers? What are the major solutions to address challenges? What are the priorities and entry points for mountain agriculture development? What are the key issues in mountain areas in the context of sustainable agriculture and food systems that draw regional attention, cooperation and policy framework to strengthen mountain agriculture development for Zero Hunger and poverty reduction?

2 Step 2: Partnership-building

Given the multi-dimensional nature of mountain agriculture, it is considered essential to build partnerships with countries with a strong desire to develop this area and organizations with shared vision and relevant expertise on mountain agriculture.

Through the facilitation of Strategic Programme 3 of FAO, the FAO established a working relationship with the University of International Relations in China, and enhanced collaboration with the International Crops Research Institute for the Semi-Arid Tropics, the International Centre for Integrated Mountain Development, Mountain Partnership, the Center for International Agriculture Research at the Chinese Academy of Agriculture Sciences and a raft of international experts including the FAO Special Ambassador of the International Year of Pulses and the Vice Chair of the High Level Panel of Experts for Food Security and Nutrition of the CFS. In terms of international partners for the Mountain Consultation, organizations with expertise from agriculture, ecology, socio-economic disciplines, and experience with mountain agriculture are the main stakeholders. Nominated international experts offered their technical expertise to review the country reports on mountain agriculture.

In terms of national partners, the government and national agricultural research councils or institutes are the main stakeholders. Participating countries include Bhutan, Bangladesh, Cambodia, India, Lao PDR, Myanmar, Nepal, Pakistan and Viet Nam. Under RI-ZH, the government plays a pivotal role in organizing and facilitating the preparation of the country studies on mountain agriculture at the national level, coordinated by the National Focal Points of Zero Hunger, including the nomination of a competent national institution and expertise to undertake and finalize each country study on mountain agriculture. For nine countries, the national

Figure 1.1 Development process of the Consultation on mountain agriculture

government or agricultural research council or institute took the lead in undertaking and finalizing the country study on mountain agriculture, i.e. Chittagong Hill Tracts Development Board in Rangamati of Bangladesh, Ministry of Agriculture and Forests of Bhutan, General Directorate of Agriculture of Cambodia, University of Agricultural Sciences and Technology Jammu in India, Upland Agriculture Research Center under the National Agriculture and Forestry Research Institute in Lao PDR, Department of Agricultural Research in Myanmar, Ministry of Agriculture and Livestock Development in Nepal, Northern Mountainous Agriculture and Forestry Science in Viet Nam, and Pakistan Agricultural Research Council in Pakistan.

3 Step 3: Preparation and review of national report on mountain agriculture

The national report on mountain agriculture focused on challenges, opportunities, the main policy measures, initiatives and practices in mountain agriculture and recommendations at a country level. Following the overall guidelines, each participating country prepared a preliminary national report on mountain agriculture at a national level according to the established guidelines. The Guidelines for Preparation of Country Reports on Mountain Agriculture Development can be found in Annex 1.

The preliminary country reports were subsequently reviewed and shared by FAO with an international panel of experts specializing in agriculture, ecology, and the socio-economic aspects of mountains. The international experts conducted a review of the preliminary national report from their respective disciplines prior to the Consultation.

In addition, national mountain agriculture experts of national research institutes from nine Asian countries were invited to prepare Country Reports on Mountain Agriculture Development Achieving Zero Hunger and Poverty Reduction, in coordination with their government officials. The reports were circulated for international review before the Consultation. With the comments received, the national mountain agriculture experts gave presentations during the Consultation for further review. Moreover, a comprehensive set of Questionnaires on Mountain Agriculture in Asia were distributed to all participants at the Consultation for data gathering and deliberative consultation. The analytical results of the Questionnaires are presented in Chapter 7 of Part II.

4 Step 4: International workshop and regional expert consultation on mountain agriculture

Under FAO RAP's Regional Initiative on Zero Hunger, the International Workshop and Regional Expert Consultation on Mountain Agriculture was

Table 1.4 Objectives and outputs of the Mountain Consultation, 30 October–1 November 2018, Beijing

Objectives	Outputs
A Identify constraints, gaps and opportunities on mountain agriculture development for poverty reduction and Zero Hunger	A1 Identified key challenges and opportunities that agriculture and food systems face in mountain areas
B Facilitate knowledge sharing, lessons learnt and good practices on agriculture development and mountain food security and nutrition governance	B1 Good practices and solutions on mountain agriculture and mountain food security and nutrition governance
C Identify possible entry points and policy recommendations promoting mountain agriculture development and strengthen food security and nutrition governance	C1 Developed recommendations and policy framework for mountain agriculture development

co-organized by the FAO and UIR, in collaboration with international and national partners, from 30 October to 1 November 2018 in Beijing. During the Consultation, each country's team presented the results of a preliminary country report on mountain agriculture. It was followed by a multi-dimensional review by international experts for each participating country. The objectives and output of the Mountain Consultation are listed in Table 1.4.

The three-day event followed the food systems approach covering key issues from production, trade and marketing through the lens of socio-economic, policy, agriculture, nutrition, ecological and environmental factors. (FAO, 2019) The first day's programme was aimed at giving international experts the chance to share advanced experiences/programmes/lessons learnt and successful stories in mountain agriculture development from a global policy and technical perspective. The event was opened by the FAO Representative in China and the President of UIR, Dr Mahmoud El Solh, who is Vice Chair of the High-Level-Panel-Experts for Food Security and Nutrition, and The Committee on World Food Security of the United Nations who delivered a keynote speech on Sustainable Mountain Agriculture Development for Food Security and Improved Livelihoods for Zero Hunger. This was followed by Professor Kraissid Tontisirin, M.D., PhD., President of Nutrition Development Foundation, who delivered Thailand's keynote on the Institutional Framework on Food Security and Nutrition Governance in Mountain Region of Thailand on Zero Hunger Perspective, and Professor Fengying Nie, Deputy Director-General, Center for International Agriculture Research of Chinese Academy of Agriculture Sciences' who gave a keynote on Strategy and Application of Precision Poverty Alleviation in Mountain Regions in China: the Role and Effect of Institutional Mechanism. Various international experts then presented state-of-art concepts and interventions under the topics of (1) Mountain Agriculture Development and Food Security and Nutrition Governance; (2) Mainstreaming

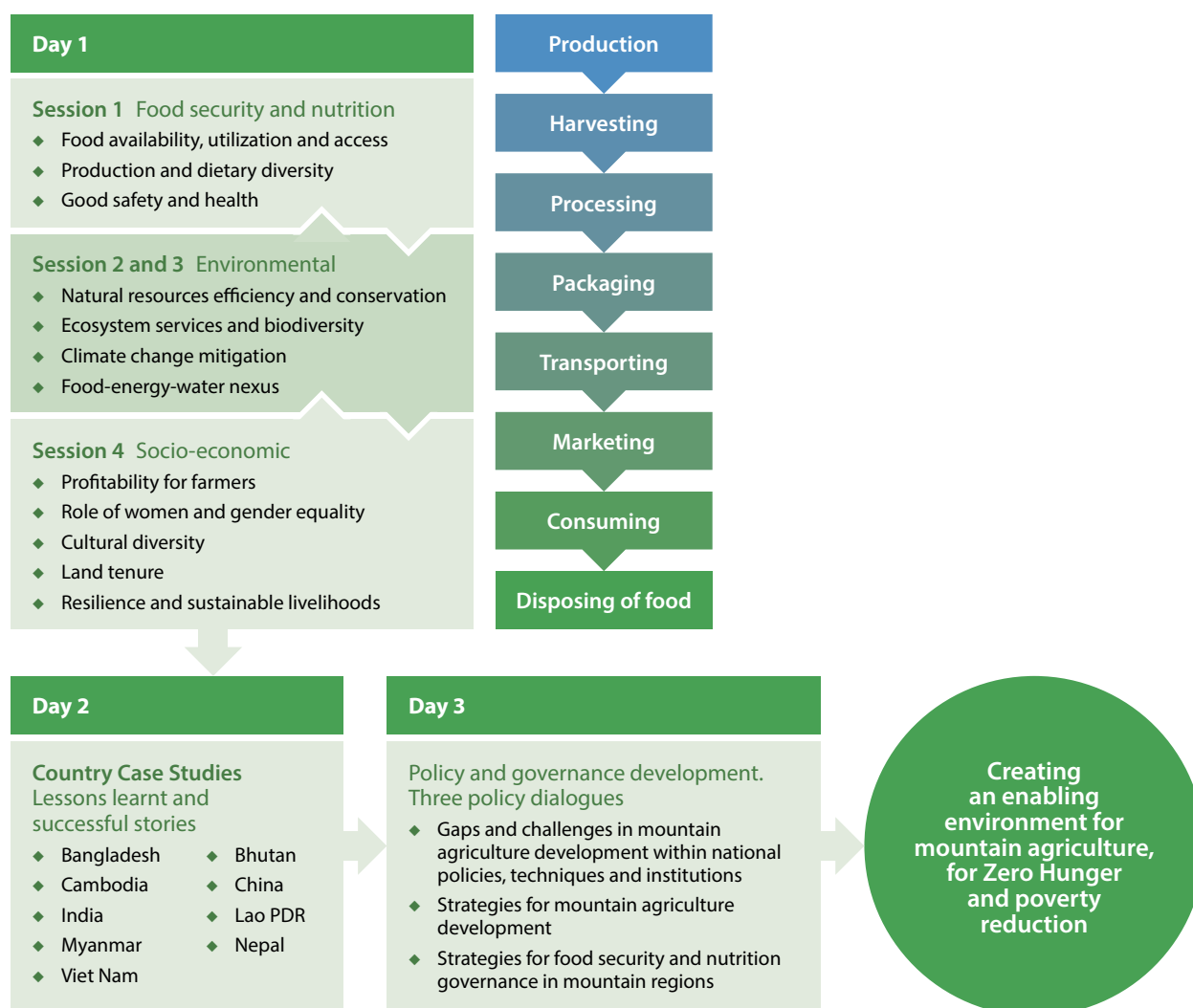
Neglected and Underutilized Species (NUS) for Mountain Agricultural Development: The role of Future Smart Food; (3) Building Sustainable and Integrated Farming Systems for Mountain Agriculture; and (4) Promoting Integrated Value Chain and Market Access for Mountain Products.

During the morning sessions on Days 2 and 3, country experts presented their preliminary national reports on mountain agriculture. Debate and deliberations continued on Day 3 in the form of three policy dialogues on (1) Gaps and challenges in mountain agriculture development within national policies, techniques and institutions; (2) Strategies for mountain agriculture development: policy, socio-economical, institutional, environmental and technical aspect; and (3) Strategies for food security and nutrition governance in mountain regions. National government representatives and international experts shared their concerns and opinions on the move towards sustainable mountain food security and nutrition governance. Dr David Molden, Director-General of ICIMOD, highlighted the need to stand up collectively for mountain issues and act as a voice for mountain people not only nationally but internationally, as mountains are hotspots for SDGs, climate change and migration.

The Consultation concluded with a set of Recommendations for Sustainable Development of Mountain Agriculture, presented by Dr Mahmoud Solh who incorporated the comments and suggestions from the Consultation on behalf of the panel of experts. The recommendations provide a comprehensive framework with concrete entry points for country implementations on sustainable mountain agriculture development (see Chapter IV on Conclusion).

Finally, Dr Daniel Gustafson, Deputy Director-General, Programme, FAO, wrapped up the Consultation with his closing remarks. (see Annex 2) He emphasized that we need to continue flying the flag for mountains and mountain agriculture in the Asia region, and we need

Figure 1.2 A snapshot of the main issues of the three-day Mountain Consultation, 30 October–1 November 2018, Beijing



to reach further, communicating globally to audiences, including policymakers, for whom the global importance of mountains and links between upland and lowland areas are imperceptible. Dr Hui Wu, Vice-President of UIR, also offered a closing remark on behalf of UIR. A snapshot of the main issues of the three-day Consultation is in Figure 1.2.

1.5 Conclusion

This introductory chapter focuses on mountain agriculture, food security and nutrition from a Zero Hunger perspective. Why does mountain agriculture deserve special attention? It stems from the special challenges and opportunities associated with the distinctive agro-climatic features of mountainous regions. Examining the four dimensions of food security, mountain agriculture offers opportunities to enhance availability, access, utilization and stability of sufficient, safe and nutritious food. In terms of food availability,

mountain agriculture has a substantial comparative advantage to increase agricultural production of sufficient, nutritious and safe food based on the vast but underdeveloped land areas, high levels of topology diversity, agro-climatic specifics of mountain regions, and different growing seasons. In terms of food access, mountain agricultural production has the potential to sustain household food needs, with surplus produce bartered for food or non-food items. An increasing level of monetary income can lead to cash availability for many mountain households to purchase food items and has thus make better food access possible. In terms of food utilization, which concerns the *nutritional status* of individuals, special and diversified mountain agro-climatic conditions enable mountain agriculture to produce a wide variety of food products, e.g. fruits, vegetables, chestnuts, pine nuts, which provide energy, protein and micronutrients to diversify diets for nutritional improvement. In terms of stability, mountain agriculture offers unique opportunities for

filling the gap that results from adverse weather conditions, political instability or other unforeseen factors. The unique and diversified agriclimes of high-altitude areas favour the cultivation of a variety of FSF and off-season crops such as vegetables of outstanding quality. To better understand the challenges and opportunities that mountain agricultures faces and offers, as well as identifying the possible entry points to turn challenges into opportunities, the FAO and its partners organized an International Workshop and Regional Expert Consultation on Strengthening

Mountain Agriculture Development and Food Security and Nutrition Governance. In the context of SDGs, to turn challenges into opportunities that mountain offers, it is the essential for governments to play a leading role and place mountain agriculture at the centre of national and sub-national poverty reduction, food security and nutrition policies to bring its potential to full fruition and to improve the livelihood of mountain population. This publication presents a regional overview on mountain agriculture development based on thematic analysis and national studies.

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Annex 1 Guidelines for preparation of country reports: mountain agriculture development achieving Zero Hunger and poverty reduction

Regional Initiative on Zero Hunger, FAO RAP

1 Guidelines for preparation of country report:

- 1) The Country Report on Mountain Agriculture Development of each country shall provide a detailed description on the status of mountain areas in the country. It shall include, but not be limited to, the:
(i) Overview of mountain areas in country, (ii) challenges for mountain agriculture development, (iii) opportunities for mountain agriculture development; (iv) country experience; (v) strategies and recommendations for mountain agriculture development. (Please refer to the **Country report outline on mountain agriculture development achieving Zero Hunger and Poverty Reduction**).
- 2) The draft report should be prepared by 15 September 2018, to allow peer review before the actual workshop. (Submitted to: Dr Xuan Li, Delivery Manager, Regional Initiative on Zero Hunger in FAO Regional Office for Asia and Pacific, xuan.li@fao.org)
- 3) Data used for the analysis in the report needs to be provided or linked to their respective sources.
- 4) Ensure that all relevant sources are utilized and that an integrated set of information is available after the scoping. Make as much use as possible of available data, studies and reports (including cases studies and success stories) and fill information gaps by using informants and other methods to gather empirical data.
- 5) Share your ideas, suggestions and comments with regard to the set criteria, parameters, food groups and table setup (e.g. what is still missing? Did you face any problems/limitations?)
- 6) In case of any queries or uncertainties, please seek direct contact with Dr. Xuan Li on skype (lixuan6182) or via e-mail (xuan.li@fao.org).
- 7) After completion, the report will be shared with relevant international experts and research institutes for review and comments for revision and finalization.
- 8) Some useful references:
 - ◆ Mountain Partnership website. <http://www.fao.org/mountain-partnership/en/>
 - ◆ Why invest in sustainable mountain development? <http://www.fao.org/docrep/015/i2370e/i2370e.pdf>

Country report outline

Mountain agriculture development achieving Zero Hunger and Poverty Reduction

I Overview

1 About the country

- 1) Physical characteristics (e.g. location, land area, elevation, agro-ecological conditions, climate and weather),
- 2) Demographics (e.g. population, indigenous groups, etc)
- 3) Economy
- 4) Hunger and all forms of malnutrition
- 5) Poverty: population below poverty line (Poverty headcount ratio)

2 About mountain in country

- 1) Physical characteristics, demographics
- 2) Economy: Major economic activities, sources of livelihood
- 3) Hunger and malnutrition in mountain areas
- 4) Poverty (Poverty headcount ratio)

3 About contributions and percentage of mountain agriculture in the country

- 1) Land: areas, types, classification and distribution; land utilization in the mountain areas (used vs fallow/wild land)
- 2) Population: Mountain areas vs national
- 3) GDP: Mountain agriculture vs country
- 4) Main mountain agricultural activities and products (crops, livestock, agro-forestry, etc)
- 5) Income: Mountain areas vs nation, sources of livelihood (agriculture vs non-farm)

II Mountain agriculture in country: status, challenges and constraints

1 Status

- 1) Land utilization in the mountain areas: Area used for agriculture production, forestry, etc.
- 2) Main farming systems in mountain areas
- 3) Crops commonly grown in mountain areas
- 4) Animal production and grazing system in mountain areas

2 Challenges and constraints for sustainable mountain agriculture: technical, economic, environment

- 1) Socio-economic factors: land tenure and land right, small and marginal landholdings; aging, labour shortages and cost, migration, population growth, aging, urbanization
- 2) Natural resources and environment pressure on the agricultural production base: e.g. climate change, natural disasters, arable land, agro-deforestation, soil (erosion, declining soil fertility), water, etc
- 3) Technical constraints for mountain agricultural production: yield gaps, productivity, input availability, etc
- 4) Market: lack of market information, channels, etc
- 5) Physical and infrastructure
- 6) Policy and institutional

III Opportunities and entry points for mountain agriculture development to address Zero Hunger and poverty reduction (food systems perspectives covering production, agro-processing, marketing and consumption)

- 1 Agriculture diversification and sustainable intensification: e.g. diversify crops from staple production to mix with Future Smart Food; shifting from monoculture to diversified and integrated farming systems, animal production and grazing systems, conservation agriculture, etc.
- 2 Agro-processing activities for agriculture products (e.g. establishing agroprocessing centres in mountain areas shortening distance to market; minimal processing)
- 3 Value-addition measures and activities for agriculture products: e.g. brands and certification for mountain agriculture products, Globally Important Agriculture Heritage Systems (GIAHS), one-village-one-product, developing links with markets, institutional procurement programmes, e-agriculture, etc.
- 4 Social protection measures targeting mountain people
- 5 Others

IV Country experience: main policies measures, initiatives and practices in mountain agriculture development

- 1 Good agricultural practices on sustainable and integrated farming in mountain areas
- 2 Policy measures and initiative for sustainable and inclusive mountain development
- 3 Case study

V Strategic consideration and suggestion: policies and measures, governance promoting sustainable agriculture development in mountain areas

- 1 Policies
- 2 Measures and interventions
- 3 Governance

VI Conclusion

Annex 2 Closing Remarks

By Dr Daniel Gustafson, Deputy Director-General, Programme, FAO

International workshop and regional expert consultation on mountain agriculture development, food security and nutrition governance

FAO and UIR

In collaboration with the FAO Special Ambassador of the International Year of Pulses, the International Crops Research Institute for the Semi-Arid Tropics, the International Centre for Integrated Mountain Development, Mountain Partnership and Center for International Agriculture Research of Chinese Academy of Agriculture Sciences

Regional Initiative on Zero Hunger

30 October – 1 November 2018
Beijing, China

Thank you very much for the introduction.

Let me start by saying it's a huge pleasure to speak here, especially as it was touch and go that I could. I am here in China for another event to commemorate the 40-years of opening-up for poverty reduction in China, and it wasn't clear that at what point of the day my talk would take place, so I didn't want to commit to this one. But I'm just delighted that I can be here and do this, for two reasons: Firstly, the issues that you discuss here on mountains are extremely important to us and it is of high priority in sustainable development. Secondly it is also an unexpected pleasure to see so many dear friends and colleagues.

All the things about mountains that I know, I have learnt from you, from the time that I lived in India and Bhutan including my time with ICIMOD. Many of you are key in this. Also I would like to point out that a number of you are old colleagues. Dr Solh and Dr Kraissid, have had, and continue to have impactful careers. Some of you know that they were both division directors of the FAO, respectively in plant production division and nutrition division. And without a question, their period as directors, set the direction in which we are still going – to look at agriculture and nutrition in a more sustainable way.

And for us, the fruit of the seeds that they sowed back then, continues to grow. It is really a pleasure. I could go on, John Dixon taught us about farming systems in those days, Dr Wani, of course, we know very well. I am particularly happy also that two of our former FAO HQ colleagues, Xuan Li and Thomas Hofer, are back again in the field. Not that they ever stopped contributing, but it is just a pleasure for me to see. And I cannot resist saying it here.

But what I am most struck by, is the similarity between what we are discussing today and the event tomorrow "40-year anniversary of opening-up in China". They are in parallel and unique in the history of mankind – delivering large-scale poverty reduction in the span of 40 years. No one thought that it was possible and mountains play a big part in it. One of the key areas is "working together in partnership". I am so pleased that our mountain agriculture projects are taking place in partnership with universities, professors in recognition that food security is in fact a security issue, which we have thought of it for a long time whereas some other part of the world haven't recognized this fact until relatively recently. It is thus an appropriate partnership with the University of International Relations in China. We are really pleased and enormously grateful for the hard work you did that went into this. We are looking into food security within the international security debate, and the mountain discussions are a huge part of this. It is just terrific.

When I look into the summary of the workshop, I think those are similar messages in each of the events, not only within the context of mountains, but also the recognition of the very large imbalance between the importance of the topic and the attention that they receive, that is the mountain population and mountain food system. It is somewhat a mystery to me still as to why it is the case. Mountains after all are not just home to a small portion of the world's population, millions live there, and mountain ranges are where an overwhelming portion of some of the solutions to modern problems can be found, with regards to biodiversity, water, and many factors. Why this unbalance?

But also when we are looking at the global picture of what we discussed today, much of what China accomplished would be very difficult to replicate, in the sense that a very large of population moved out of agriculture to urban areas and into industry. And the result was a transformation of the economy. So what you have is a much greater pressure in employment, especially youth employment. But not much increase in productivity for those left behind in the rural areas. So how to overcome this? We need to learn from China's experience. You need targeted pro-poor policies, infrastructure, human capital and among other things, some social protection policies, not only for the development of human capital, but also to prevent people from falling back into poverty.

Within this context, the mountain situation is exemplary in this regard. What we are looking for, even in the plains, are value addition or high value products that are location specific, so we can move away from non-differentiated cereals. In particular, addressing Professor Siddique here, the International Year of Pulses had big impact in increasing the consumption and production of pulses. It has exceeded our expectations in what we can do to promote certain commodities. So how can we bring this attention to mountain and mountain products, in the way that takes advantage of their unique value? How can we ensure that the rest of the world sees the value of mountain goods? People do value mountain products, they see that something come from the Himalayas, for example, as something special. And it is common for all countries in this area. So how can we turn the value of the area-specific products into benefits for the people who live here, not only in terms of production, but also, processing, transportation, distribution, tourism, marketing and so on?

In fact, we have good examples of it. Many of you know it from your countries' GIAHS. These heritage sites tend to be in mountains because of the specific mountain products that consumers and tourists (international and local) really want. So how can we use that model, say an agroterritorial approach, in a way that is beyond production but which has received a lot of value addition and employment for youth to generate agroforestry related but non-farm livelihoods that are related to these products? And I think that the recommendations that you just went through now are very similar to what we want to see globally. It would be not good just for Asia, but also for example, for mountains in Africa – empowering empower farmers and women, diminishing conflict and improving food security, employment and resilience. It is an outstanding project.

I am delighted to say that it is fantastic to have 10 countries represented here. I think that's probably more than what we had before with Mountain Partnership. We all knew from the beginning that the Mountain Partnership was a great thing, everyone loves it. But there was a worry that the Partnership hadn't attracted enough attention and not many countries had signed up. So I hope you can go back to your country and share your enthusiasm for the Partnership.

As I said, it is a semi-unexpected pleasure to speak on behalf of the organization. And thank you for your contribution and thanks again to the university and the organizations from our side. We look forward to seeing the fruits of your deliberations turning into food security, less conflict, more water, more biodiversity and so on and on. Thank you all very much.



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Part II

ENABLING
ENVIRONMENT
REQUIRED TO
PROMOTE SUSTAINABLE
MOUNTAIN AGRICULTURE
DEVELOPMENT



2 The status, opportunities and challenges of mountain agriculture development to improve livelihoods and ensure food security and Zero Hunger

Mahmoud El Solh, Vice Chair of the Steering Committee of the High-Level Panel of Experts on Food Security and Nutrition of the United Nations Committee on World Food Security (HLPE-CFS)

2.1 Global challenges and the role of mountains

The world is facing more challenges than ever including poverty, hunger and malnutrition, degradation of natural resources and ecosystems, population growth, climate change, a growing demand for food and energy, water scarcity and desertification, loss of biodiversity, rural to urban migration, and the rapid growth of cities. But more sustainable systems of mountain agriculture could help meet these challenges.

The FAO views mountain ecosystems as essential building blocks for long-term sustainable global development and poverty alleviation, as well as a means of transition to a green economy (FAO, 2011). Mountains are a vital source of freshwater and are increasingly important in the creation of renewable energy. So the sustainable development of mountain ecosystems and agriculture should be a global priority in a world facing water, food and energy crises (FAO, 2011; FAO, 2013).

Mountains cover more than 22 percent of the earth's land area (Figure 2.1) and are home to 915 million people, or about 12 percent of the world's population, according to Mountain Partnership (ICIMOD, 2018; FAO, 2011; FAO 2018a). About 39 percent of mountain populations live in developing countries, with most of these inhabitants living below the poverty line. They are, therefore, highly vulnerable to food insecurity. According to the recent FAO/Mountain Partnership Secretariat study, one out of three people living in mountain areas in developing countries is food insecure, which is reduced to one out of two in rural mountain areas (FAO, 2011). The study revealed that the number of vulnerable people increased by 30 percent from 2000

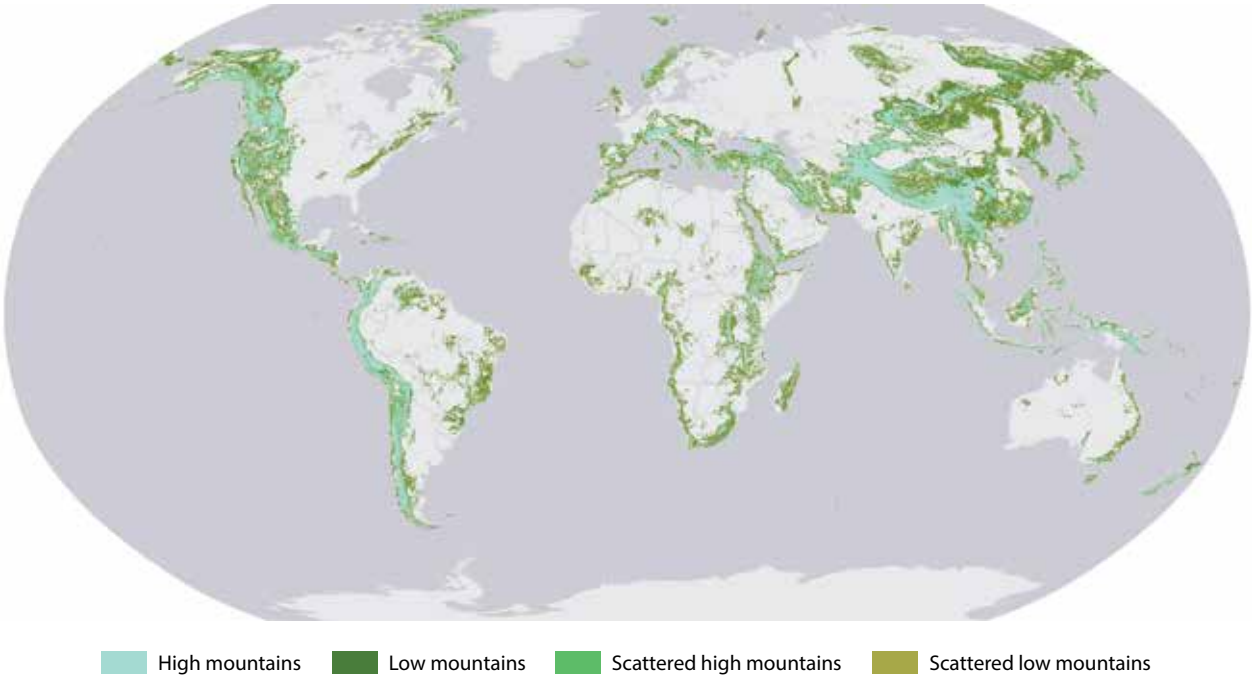
to 2012, while the mountain population increased by 16 percent, which illustrates an increasing trend in the number of vulnerable people.

To achieve sustainable mountain development, the environmental, economic, social, cultural and political challenges facing mountain areas need to be addressed using a holistic approach (FAO, 2011). This will not only enhance food security for poor mountain communities but also substantially contribute to global food security.

2.2 The importance of mountain ecosystems for the global environment, food security and livelihoods

Mountains provide many important resources and ecoservices to meet the needs of a substantial part of the world. Systems of sustainable mountain development not only target mountain communities but can also have a global impact (FAO, 2011), and improvements in mountain ecosystems positively impact the livelihoods of both local mountain communities and people residing in the lowlands. A model of the symbiotic relationship between the mountains and lowlands was developed by the International Centre for Integrated Mountain Development (ICIMOD), which has its headquarters in the mountainous area of Kathmandu, Nepal. The model shows the different zones from the mountain sources, which provide resources and services, to the river delta (Figure 2.2). Only a proper system of management will ensure that mountain resources are conserved for future generations.

Figure 2.1 Mountains of the world



Source: Esri DeLorme, NAVTEQ

Figure 2.2 The different zones of a typical river basin and cryosphere model representation showing the different resources and services provided by mountains



Source: ICIMOD Programmes, river basin and cryosphere, www.icimod.org/?q=9122, retrieved on 7 January 2019

Figure 2.3 Mountains are an important source of fresh water

© Shutterstock/martinho Smart

Figure 2.4 The elevation and altitude gradient of mountains provide various sources of renewable energy including hydropower, solar energy and wind power

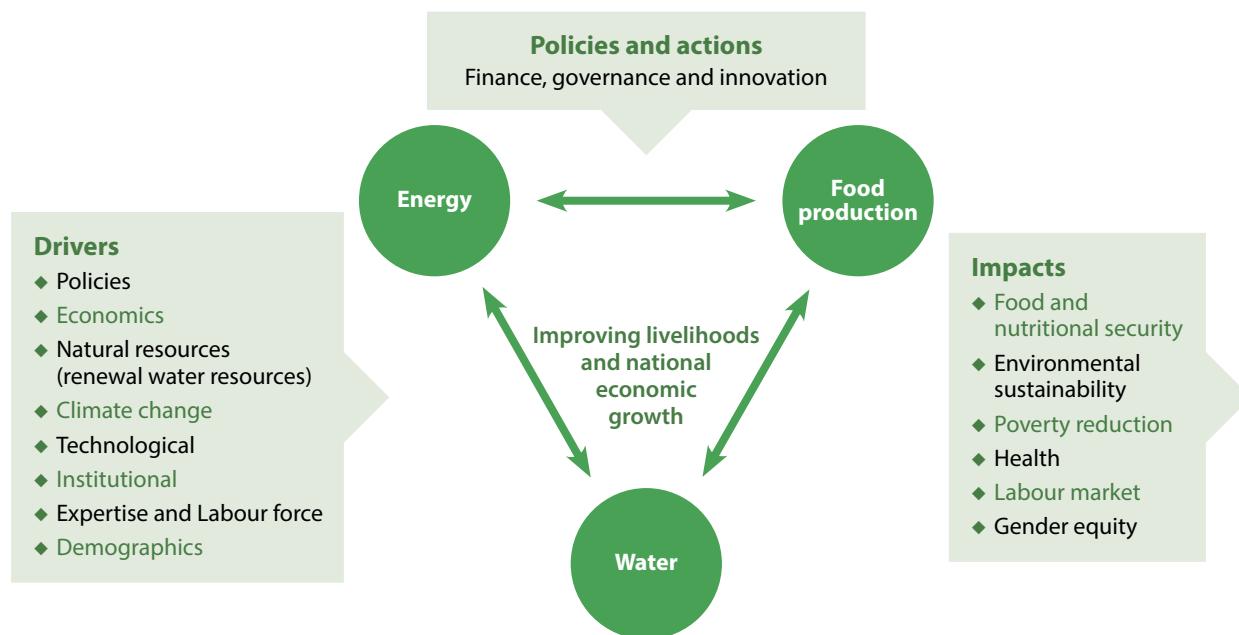
Mountain areas are characterized by topography of variable altitudes and variable climatic conditions and so are major reservoirs of global biodiversity.

Mountains are characterized by a wide range of climatic and agro-ecological diversity from dry, high-altitude deserts to tropical rainforests in the highlands, and from permanent ice and snow at altitudes above 9 000 m, to diverse climatic conditions of 1 200 mm precipitation (FAO, 2011).

The world's mountains are its water reservoirs, providing about 70 percent of the world's freshwater resources to around half of the world's population for domestic use, agriculture and industry (FAO, 2011). Mountains are important watersheds, conserving snow cover and

releasing water slowly to feed streams and rivers throughout the year all over the world (FAO/Mountain Partnership). This makes mountain ecosystems a vital source of irrigation water, which is essential for crop and livestock production both up- and down-stream to enhance food and nutritional security.

Increasingly, mountain ecosystems are key sources of different types of renewable energy including hydropower, solar energy, wind power and biomass fuels. Streams and rivers along mountain altitude gradients provide hydropower that generates electric power, which is important for various sectors and helps to improve livelihoods (FAO, 2011). Similarly, wind flow and circulation, and high solar radiation in the mountains provide renewable sources of wind and

Figure 2.5 The drivers and impacts of the Water–Energy–Food Nexus in which mountains play an important role

Source: Adapted by M. El Solh from Al-Riffai *et al.*, 2017, Hoff, 2011 and von Braun, 2015.

solar energy. Renewable energy is valuable as it reduces the environmental pollution generated by non-renewable energy.

Mountain areas are rich in biodiversity, containing one-third of all plant species and hosting 17 (50 percent) of the 34 global biodiversity hotspots. Almost two-thirds (322) of all biosphere reserves and one-third of the UNESCO World Heritage Sites are fully or partially located in mountain areas (FAO, 2011).

2.3 The importance of mountains to the Water–Energy–Food Nexus

Mountain resources provide fresh water and renewable energy, and are essential for the Water–Energy–Food (WEF) Nexus. The Nexus outlines the drivers that can improve livelihoods and economic growth based on appropriate policies and actions addressing water, energy and food production (Figure 2.5). Positive impacts resulting from these policies and actions are essential for reaching the Sustainable Development Goals (SDGs), including reducing poverty and eliminating hunger at national and global levels. The WEF Nexus highlights how critical it is that policymakers and stakeholders consider these drivers and understand how investment in mountain ecosystems can enhance national and global economic growth and improve livelihoods, especially as world faces increasingly difficult crises in water, food and energy.

2.4 Mountain agriculture and farming for improved food security and livelihoods

In mountain areas, agriculture is the main source of livelihoods despite the challenges of a harsh environment, climate change implications, inadequate infrastructure and isolation that hamper farmers' productivity and access to markets.

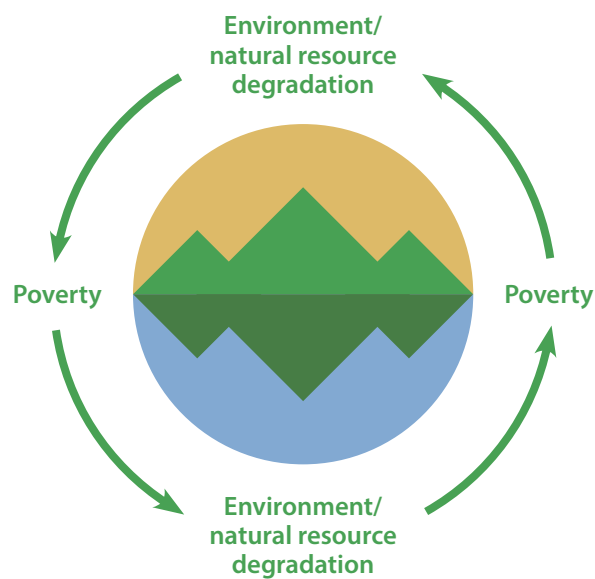
Other than pastoral production systems, which rely on natural pastures, mountain farming is feasible and practiced either on highlands with relatively flat plateaus (e.g. the Ethiopian highlands) or on terraces, which are a series of flat platforms resembling wide steps. Terraces are established on sloping landscapes in mountain areas for more effective farming (Figure 2.6), are used in both mountain rainfed and irrigated farming to reduce erosion and water runoff. Broad terraces can only be built where the incline of the mountainside is less severe. The steeper the slope, the narrower the terraces have to be. Yemen's mountains provide an example of narrow terracing on very steep mountains with platforms of just two to three metres. This method of mountain farming has been in use for centuries and the impressive rice terraces of the Philippine Cordillera are a designated as a UNESCO World Heritage Site due to the importance of this technique in agriculture and human development (Figure 2.6).

Figure 2.6 Terrace design showing the relatively wide rice terraces in the Indonesia and narrow terraces (1 to 2 metres) in the steep mountains of Yemen



Source: https://en.wikipedia.org/wiki/Terrace_agriculture#/media/File:Inca_terrace-en.png

Figure 2.7 The cycle of poverty – natural resource degradation – poverty in mountain areas



2.4.1 The challenges facing mountain agriculture and ecosystems

Mountains are fragile ecosystems where populations face a range of challenges, including:

- ◆ Policy marginalization
- ◆ Poverty
- ◆ Overexploitation of natural resources
- ◆ Food insecurity
- ◆ Climate change impacts
- ◆ Water scarcity and drought
- ◆ Natural resource degradation
- ◆ Soil and fertility erosion
- ◆ Excessive grazing of rangelands
- ◆ Loss of biodiversity
- ◆ Desertification

- ◆ Natural disasters and landslides
- ◆ Migration
- ◆ Ecosystem degradation

2.4.2 The vicious cycle in mountain areas

There is a vicious cycle in mountain areas: natural resource degradation – poverty in mountain areas. The higher the poverty level in a mountain community, the greater the exploitation of natural resources, namely soil, water and biodiversity. This leads to higher degradation of these resources and the local community becoming poorer as a result (Figure 2.7). The challenge for national authorities is to develop policies and invest in programmes that ensure the sustainable development of mountain agriculture and ecosystems. This breaks the cycle and protects the natural resource base from degradation, thereby improving the livelihoods of people in poor communities.

2.4.3 Production systems in mountain agriculture

Mountain agriculture includes the following production systems:

- ◆ Pastoral livestock production system
- ◆ Agro-pastoral production system
- ◆ Rainfed agricultural production system, including fruit trees
- ◆ Irrigated agriculture production system, including fruit trees

Forestry, while not covered in this chapter, is another important source of livelihood in mountain areas and provides essential environmental goods and services, such as timber, fuelwood, carbon storage and other products that improve the lives of people living in mountain communities (FAO, 2011). Forests also capture and store precipitation, regulate the flow of groundwater and stabilize steep slopes, which protect the soil from erosion and help prevent natural hazards in the mountains, such as landslides and avalanches.

2.4.3.1 Pastoral livestock production system

The pastoral livestock production system is important for global food security, particularly in mountain areas. This grazing-based system occurs on natural vegetation and rangelands that include grasses, legumes, shrubs and other vegetation to provide forage for livestock throughout the year. This system remains an important contributor to food security despite the degradation of rangelands and loss of biodiversity due to excessive grazing and soil erosion. Rangelands are more suited to livestock grazing than crop cultivation and they occupy 40 percent of the 13.7 billion hectares of the earth's land surface and can be found on every continent (Sheehy *et al.*, 2006).

In Asia, a good example of the importance of rangelands is the Tibetan Steppe. Much of the steppe lies within China although it extends into north-western Bhutan, northern Nepal and north-western India. The Tibetan steppe covers a vast area, extending about 1 500 km from north to south and 3 000 km from west to east. This equates to about 165 million hectares (25 percent of China's land area), or 42 percent of China's grazing land (Sheehy *et al.*, 2006). The Tibetan steppe has several distinct topographic regions determined by the parallel mountain ranges that divide it and the water drainage patterns (Figure 2.8). The Himalayan Mountain range marks the southern boundary of the steppe and a series of three mountains delineates its northern boundary (Sheehy *et al.*, 2006).

Historically, grazing on the Tibetan steppe goes back 4 000 years. According to Sheehy *et al.* (2006), pastoralism in this steppe was originally developed by nomads from Central Asia who brought their herds of sheep and goats for grazing. Currently, herders on the plain are Tibetans with small groups of Mongolians and Kazakhs. Most rangelands in the Tibetan steppe are above 4 000 m high and the environment can be harsh. Despite the challenging climate, the rangelands provide forage for an estimated 12 million yak (*Bos grunniens*) and 30 million sheep and goats that support the livelihoods of about 5 million pastoralists and agro-pastoralists (Sheehy *et al.*, 2006). The Tibetan steppe is the only source of nutrients for livestock, except for small amounts of hay and concentrates that grow locally and are important in the agropastoral livestock system.

Traditionally, nomadic herders move their livestock from one place to another to maintain the rangelands through extensive grazing management, which are important for livestock productivity. Pastoralists, in general, keep a mix of species in their herd (Figure 2.9), including yak and yak-cattle crosses, sheep, goats and horses. Domesticated yaks, an important source of milk, are highly adaptable to the harsh cold weather conditions at extreme altitudes in parts of the Tibetan steppe.

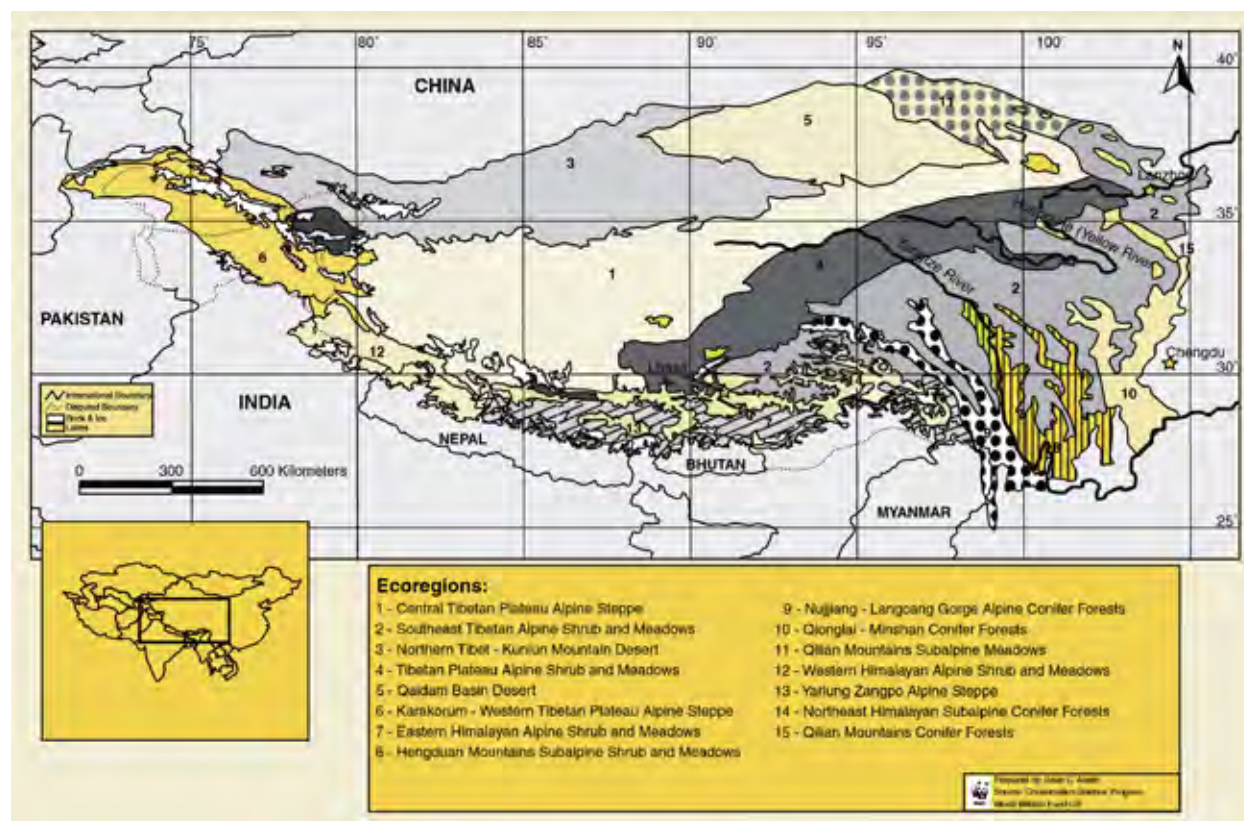
Livestock production is an important source of milk and meat that contributes greatly to the food and nutrition security of the nomad communities and other populations of the Tibetan steppe, as well as communities in the surrounding lowlands. Sheep are a good source of wool while goats yield cashmere. Horses are an important means of transport in mountain areas and are not eaten.

As well as its natural pastures, which are a major source of livestock feed, many major rivers originate in the Tibetan Steppe – including the Yellow, Yangtze, Mekong, Salween, Indus, Sutlej, Ganges, and Brahmaputra rivers. These rivers are major sources of fresh water in Asia and are important for hydropower, as irrigation water for the vast areas of irrigated agriculture, and for domestic and industrial use. Millions of livelihoods depend on these river water sources.

However, the traditional forage-based pastoral production system, which has existed for thousands of years on the Tibetan Steppe and has been extensively managed, is now declining in terms of the overall productivity of rangelands. Excessive grazing and climate change have resulted in a 30–40 percent degradation of



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Figure 2.8 Major agro-ecologies in the Tibetan Steppe

Source: World Wildlife Fund as cited by Sheehy *et al.*, 2006

Figure 2.9 Major livestock species in the Tibetan Steppe: yak, sheep and goats

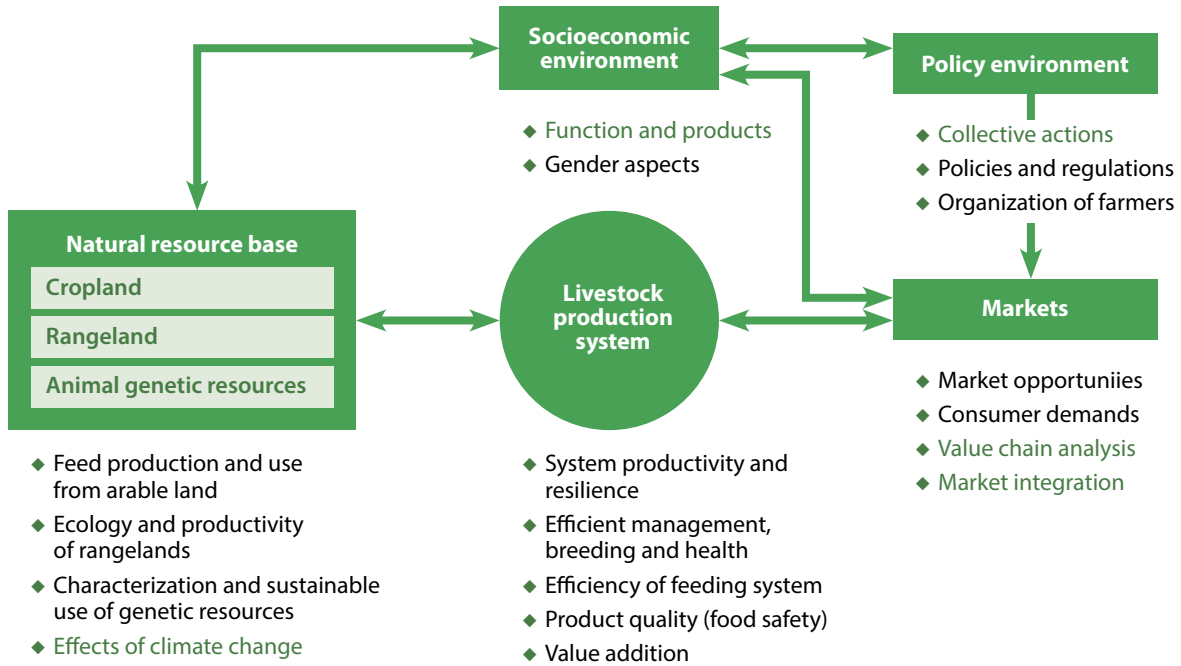
rangelands on certain plateaus. It is essential to halt and even reverse rangeland degradation, not only on the Tibetan Steppe but also globally. Due to this pattern of rangeland degradation, livestock production systems are shifting from pastoral to agropastoral systems.

2.4.3.2 The agropastoral livestock production system

The agropastoral livestock production system is an integrated crop–livestock–rangeland production system that includes livestock of different types and of diverse genetic resources, various field crops, shrubs and trees and natural pastures. The agropastoral system provides different sources of feed that are well managed to ensure efficient and high livestock productivity. The

integrated system involves the socio-economic environment, policy environment and a market component (Figure 2.10) (Iniguez, 2011), all of which incorporate different factors to ensure an efficient and productive livestock system. These factors working together allow the system to succeed economically, socially and environmentally in terms of food and nutrition security, farmer income and the livelihood of farmers, pastoralists and producers.

Crop-livestock integration is a crucial element of mountain agriculture, which uses the available natural and farming resources for both crop and livestock production. The International Center for Agricultural Research in Dry Areas (ICARDA) has

Figure 2.10 The various factors involved in the integrated crop–livestock–rangeland production system role

Source: Adapted by Barbara Rischkowsky and M. El Solh from Iniguez, 2011

Figure 2.11 Successful technologies in the agro-pastoral livestock production system

Source: Courtesy of The International Center for Agricultural Research in Dry Areas (ICARDA)

Figure 2.12 Rainfed rice production in the highlands of Nepal and rainfed wheat in the highlands of Ethiopia

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developed and refined successful technologies and management methods (Figure 2.11) (El Solh, 2014) to effectively integrate crop–livestock–rangeland production systems to enhance food security and improve livelihoods. These methods include:

- ◆ Natural pasture enhancement and rangeland management and rehabilitation
- ◆ Barley production with alley cropping of fodder shrubs
- ◆ On-farm feed production
- ◆ Feed blocks produced from agro-industrial by-products
- ◆ Growing spineless cactus and fodder shrubs
- ◆ Increased animal productivity through improved animal health and nutrition, better use of genetic resources in community livestock breeding with indigenous breeds, and improved flock management
- ◆ Development of and better access to markets
- ◆ Rehabilitation of degraded rangelands and improved grazing management

2.4.3.3 Rainfed agriculture production systems

Mountain farming can be either rainfed or irrigated agriculture. Rainfed agriculture is practiced in areas that receive more than 400 mm of rain during the rainy season in both tropical and non-tropical areas.

Both rainfed and irrigated agriculture in mountain areas are facing priority challenges in terms of soil erosion and nutrient loss. The sustainability of soil productivity, and soil and water conservation is important in rainfed

agriculture. Measures to prevent land degradation and increase soil fertility in mountain areas include reducing slope length and steepness by:

- ◆ Using different types and lengths of terracing that take into consideration the steepness of mountain slopes
- ◆ Diversifying cropping systems
- ◆ Intercropping
- ◆ Using zero tillage or conservation agriculture
- ◆ Planting nitrogen-fixing crops such as legumes
- ◆ Planting along contour lines to catch rainwater and reduce soil erosion (FAO, 2011)

Rainfed crops grown in mountain areas include cereals, such as barley, maize, rice and wheat (Figure 2.12); legumes, such as chickpeas, peas and lentils; and horticultural crops, such as fruit trees, grapes, vegetable crops and medicinal plants.

Conservation agriculture is an approach used in rainfed agriculture worldwide, and includes minimum soil disturbance/zero tillage, stubble retention, and crop rotation (legumes, oilseeds). It is important for conserving soil moisture and reducing soil erosion in rainfed agriculture production systems. The advantages of conservation agriculture include savings on fuel and machinery wear, less time between crops, reduced soil erosion, improved soil structure, soil moisture conservation, improved trafficability (a soil capability to support agricultural traffic without degrading ecosystems), timely sowing and higher yield potential, particularly in drier seasons.

Figure 2.13 Ridges of irrigated high-value saffron in the highlands of Afghanistan (left photo), saffron flowers (middle), and Afghani women collecting saffron filaments as a high-value spice for the export market (right)



Source: DFID-UK Project for Alternative Livelihoods in Afghanistan implemented by ICARDA

Figure 2.14 Plastic greenhouses for the production of high-value off-season vegetables on the narrow terraces of the steep mountains in Yemen



Source: Arabian Peninsula Regional Project implemented by ICARDA and supported by the Arab Fund for Economic and Social Development, AFESD; and International Fund for Agriculture Development, IFAD

2.4.3.4 Irrigated agriculture production systems

Irrigated agriculture systems occur in arid and semi-arid mountain areas where rainfall is too low (less than 350 mm) to support agriculture and where irrigation water is available. The sources of irrigation water are either deep artesian wells, surface water from rivers, or harvested rainwater in macro water catchments and dams. In addition, so as to cope with droughts and to reverse climate change impact, farmers can also benefit from very simple solutions, such as using cisterns to store rainfall water for drinking and irrigation (FAO, 2019). Field crops such as rice, wheat and maize are cultivated under irrigation in semi-arid mountain areas, where full and supplemental irrigation is practiced to complement the low rainfall, particularly to break the long periods of drought. In arid mountain areas, fully irrigated crops are important for food security, but do not provide the high incomes of cash crops. Therefore, farmers in irrigated mountain agriculture tend to diversify production with high-value crops including vegetables, fruit trees and ornamentals. In addition to increasing income, diversification of the cereal-based system contributes to improving human nutrition. Diversification with fruits and vegetables provides micro-nutrients and vitamins,

and diversification with nitrogen-fixing legume crops such as peas, lentils, chickpeas, common beans and mung beans enrich the soil with nitrogen. Food legume crops provide high-protein seed, which is important for human nutrition, particularly in low-income mountain communities where meat is a rare luxury.

One high-value crop that is grown in the highlands of Afghanistan is saffron, which is a high-value spice (Figure 2.13). Saffron is an alternative crop to opium poppies and can provide high income to farmers and their families, especially women in remote Afghanistan mountain areas.

In the steep mountain areas of semi-arid and arid zones of Yemen, farmers have long built narrow terraces for irrigated cropping. Water sources include deep wells and water harvesting in macro-catchments. High-value crops grown on these narrow terraces include coffee, fruit trees, vegetables and 'kat' shrubs (a legal drug). In additions, off-season vegetables crops are produced in plastic greenhouses (protected agriculture) on these narrow terraces (Figure 2.14). The production of high-value crops, particularly off-season vegetables,

Figure 2.15 Added-value mohair fibre production by Tajik women from indigenous goat breeds in the mountain areas in Tajikistan



Source: Courtesy of ICARDA

not only provides high income to traditionally low-income mountain communities but also is important for improving human nutrition.

2.5 Added-value products in mountain agriculture

Added-value products that are generated in various production systems in mountain agriculture are important for increasing income and improving livelihoods in isolated low-income mountain communities. Added-value products in livestock-based production systems (in both pastoral and agropastoral livestock production systems) include dairy products such as yogurt and cheese produced from cow, goat and sheep milk. It is important to train people, particularly women, on how to produce high-quality hygienic yogurt and cheese to fetch high market value and increase the income of mountain communities.

Another example of a high-value product is **fibre production** from sheep and goats. **Wool** from sheep is used to produce rugs that are produced traditionally and locally by mountain women. Mohair yarn is produced from indigenous goats. Enhancing processing and organizational skills to improve wool and mohair quality and market access would contribute to higher incomes in mountain communities. Developing fair trade export

markets for locally produced yarn, clothing and fibre handicrafts would increase production demand and improve livelihoods.

In the mountain areas of Tajikistan, Tajik women have undergone training to spin and create high-quality mohair products (Figure 2.15). This has enabled women to set up and develop local businesses. The approach followed in Tajikistan could be replicated in rural mountain communities in Central Asia for merino, cashmere and cashgora. These products are in high demand in the export market. Mohair yarn developed by Tajik women in mountain areas is now marketed at the same wholesale price (USD 140 per kg) as Australian mohair yarn.

An example of an added-value crop in irrigated agriculture production systems is mint, which is produced in Afghanistan for use fresh or dried, or produced as water mint and oil mint. Fresh mint is produced in plastic greenhouses (Figure 2.16), and, similar to saffron, is an alternative to opium production that has traditionally prevailed in Afghanistan. Water mint and mint oil are produced by local Afghani women who distil the fresh mint. Both water mint and mint oil fetch high prices in local and export markets because of their medicinal properties for helping to cure stomach aches and diarrhoea. If water mint and mint oil are exported to Pakistan, both can sell for high prices.

Figure 2.16 Minister of Agriculture of Afghanistan visiting the plastic greenhouses where fresh mint is grown in Afghanistan (left photo); women distilling fresh mint to produce both water mint and oil mint (middle); and vendors of water mint and oil mint in Kabul, Afghanistan (right)



Source: DFID-UK Alternative Livelihoods Project in Afghanistan implemented by ICARDA

Figure 2.17 Mountain women collecting water (left) and straw for fuel (middle), and harvesting vegetables in plastic green houses (right)



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2.6 The role of women in mountain agriculture

Mountain agriculture relies on family farming systems that include men and women. However, women generally have a larger workload than men since they are also responsible for the collection of water, straw and wood for fuel and fodder, crop harvesting, food preparation and the care of children (Figure 2.17). Mountain women face similar challenges to those in rural areas of developing countries such as limited access to education, health care and restricted involvement in decision-making. They lack economic independence and rarely have tenure rights to land (FAO, 2011). Furthermore, the situation for mountain women is aggravated by the high altitude and steep terrain, lack of infrastructure and isolation of mountain communities, along with added hardships from the negative impacts of climate change, environmental degradation and deforestation (FAO, 2011).

Seasonal outmigration of men for short and/or long periods for herding purposes or to lowland cities for work results in added responsibilities and burdens for mountain women, who become the head of their household during these periods of absence. Despite

the added responsibilities, most women are not given authority to benefit from bank loans, subsidies or other forms of government assistance.

2.7 The role of the United Nations and international organizations in enhancing mountain ecosystems and agriculture

Several organizations are involved in enhancing mountain ecosystems and agriculture at the global and regional level. These organizations work closely with countries where mountain areas constitute a substantial part of the topography and ecologies. These organizations include the FAO, which focuses on supporting mountain agriculture along with its global mandate to develop agriculture worldwide. FAO also hosts the intergovernmental Mountain Partnership established to enhance mountain ecosystems, including agriculture. Another important organization that specifically supports the enhancement of mountain ecosystems and agriculture is ICIMOD with a regional mandate focusing on the Himalayan region. The Consultative Group of International Agricultural Research Centers (CGIAR), a global research partnership, includes

ICARDA, which contributes to mountain agriculture through highland research programmes focusing on non-tropical dry areas. However, CGIAR centres need to invest more in research to enhance mountain agriculture in different parts of the world.

2.7.1 FAO's role in sustainable mountain agriculture development

Since the late 1970s, FAO has had a mandate to help preserve natural resources while ensuring food security, and people's livelihoods. The organization pays special attention to the social, economic and environmental dimensions to ensure sustainable mountain development (Marquis *et al.*, 2012; Ceci *et al.*, 2011). At the United Nations Conference on Environment and Development held in Rio de Janeiro in 1992, the UN General Assembly designated FAO as the lead organization and the task manager for Chapter 13 of Agenda 21 on "Managing Fragile Ecosystems Sustainable Mountain Development" (Marquis *et al.*, 2012). This decision was based on the FAO's mandate.

During the World Summit on Sustainable Development held in Johannesburg in 2002, the FAO was also designated as the lead agency to organize the International Day of Mountains (IDM) and was given the mandate to lead the observation and coordination of the IDM celebration, held annually on 11 December. During the World Summit in Johannesburg, the FAO also was assigned to host the Secretariat of Mountain Partnership, which was launched at that event in 2002 (Marquis *et al.*, 2012).



FAO participated in drafting Chapter 24: Mountain Ecosystems in the Millennium Ecosystem Assessment. In addition, FAO contributed to the work programme on mountain biological diversity of the Convention on Biological Diversity. They have progressively built up a conceptual and operational framework for watershed management, sustainable mountain development, forest hydrology and the interaction between these elements of stewardship in mountain regions.

In line with the main conference themes of Rio+20, FAO was assigned the role of exploring the global resource footprints of agriculture and food systems as well as developing systems of Climate-Smart Agriculture (CSA) globally (Marquis *et al.*, 2012). This role included the development of Climate-Smart Mountain Agriculture. CSA is a holistic approach that covers important environmental issues such as the sustainable use of natural resources, including water, soil and biodiversity; and energy. In addition, CSA covers social and economic issues such as gender and ways that resource-poor farmers could earn higher incomes. CSA aims to achieve the four dimensions of food security: availability of food, access to food, utilization of food for adequate nutrition, and ensuring the stability of food supply (Marquis *et al.*, 2012).

2.7.2 The role of Mountain Partnership in sustainable development

Mountain Partnership was launched during the World Summit on Sustainable Development held in Johannesburg in 2002. It advocates global attention and commitment to achieve sustainable mountain development with the following definition and mission:

The Mountain Partnership is a vibrant voluntary alliance of governments and organizations committed to working together with the common goal of achieving sustainable mountain development around the world. By tapping the wealth and diversity of knowledge, information, and expertise of and between its global memberships, the Mountain Partnership stimulates concrete initiatives at all levels to address threats, improve quality of life and sustain healthy environments in the world's mountain regions".

"Mountain Partnership members envision a world with increasing public and private sector attention, commitment, engagement, and investments in sustainable mountain development that:

- ◆ Maintain and enhance the conservation, health, vitality and stewardship of mountain ecosystems for their inherent value and for the mutual benefit of mountain communities and those who live in the larger geographic regions which include mountains;
- ◆ Improve the social and economic well-being and livelihoods of, and opportunities for, both mountain peoples – particularly the most vulnerable – and those who live in the larger geographic regions which include mountains; and

- ◆ Empower and enable mountain peoples to be fully engaged in the decision-making processes that determine the future of mountain communities and ecosystems, particularly in light of global change and globalization processes.”



Source: Mountain Partnership

The Mountain Partnership Secretariat is hosted at the FAO in Rome and facilitates the mobilization of resources and investment to support mountain people, environments and ecosystems. The Secretariat organizes analytical studies on poverty and food security in mountain areas globally and has established a database on indigenous mountain products, documenting descriptive labels, collecting traditional stories behind the products and promoting their high food quality and uniqueness. Members of Mountain Partnership are involved in the annual International Mountains Day.

Mountain Partnership also monitors the implementation of the SDGs by member countries. Mountains are mentioned in three related targets in “Transforming our world: the 2030 agenda for sustainable development”:

Target 6.6: By 2020, protect and restore water-related ecosystems, including mountains, forests, wetlands, rivers, aquifers and lakes.

Target 15.1: By 2020, ensure the conservation, restoration and sustainable use of terrestrial and inland freshwater ecosystems and their services, in particular forests, wetlands, mountains and drylands, in line with obligations under international agreements.

Target 15.4: By 2030, ensure the conservation of mountain ecosystems, including their biodiversity, in order to enhance their capacity to provide benefits that are essential for sustainable development.

Source: Mountain Partnership, (FAO, 2018a)

There are five specific goals that will be undertaken from 2018–2021, mainly by Mountain Partnership members with the support of the Mountain Partnership Secretariat, where relevant, and at the global level:

- 1 Ensure that mountain regions are fully integrated into national and international efforts to implement Multilateral Environmental Agreements (MEAs).
- 2 Build on synergies with other coalitions and create a coalition for vulnerable ecosystems.
- 3 Ensure visibility of mountains in relevant international, regional and national activities.
- 4 Raise visibility of the Mountain Partnership’s work on sustainable mountain development through communication activities and outreach.
- 5 Attract increased financial support for and investment in sustainable mountain development.

Source: Mountain Partnership, (FAO, 2018b)

2.7.3 The role of ICIMOD in sustainable mountain development

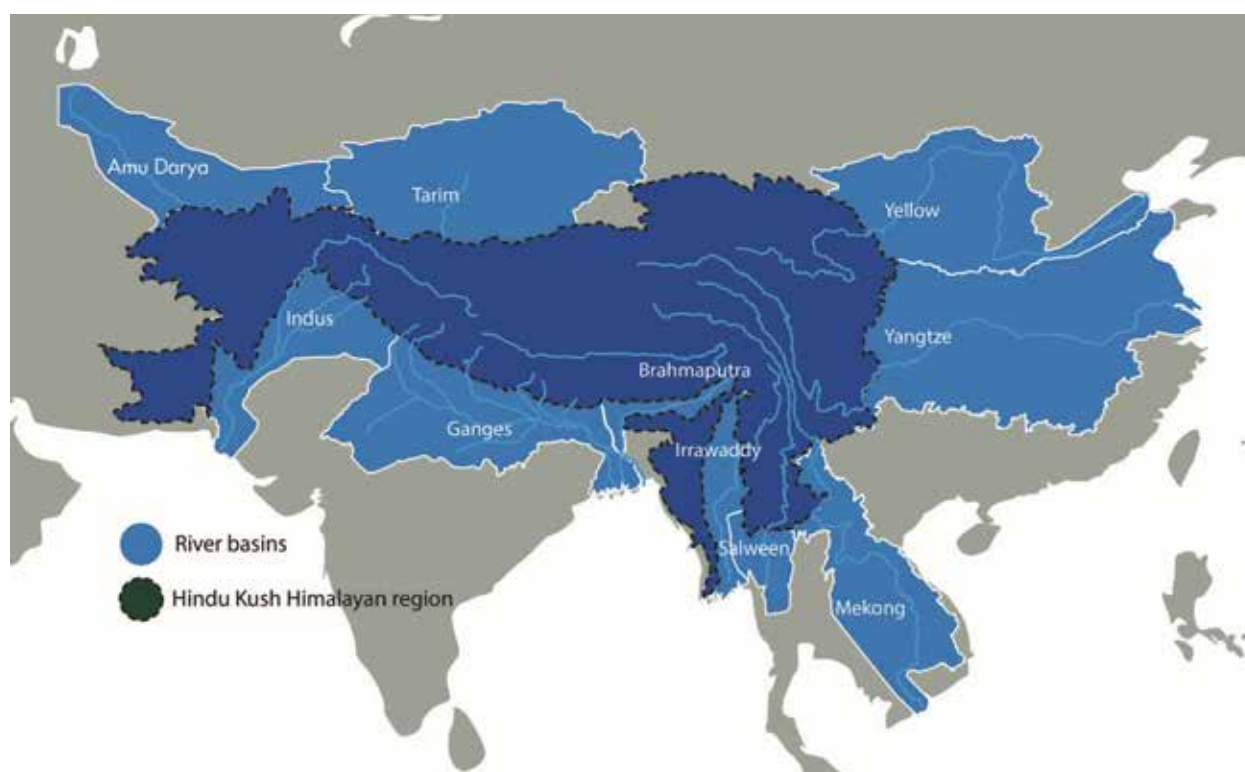
ICIMOD is a regional mountain knowledge, learning and enabling centre that helps support the sustainable development of mountains and people. With its mandate, it plays an important specialized role in the sustainable development of mountain ecosystems and agriculture in the Hindu Kush Himalayan (HKH) Region (Figure 2.18). The region is a global asset for food, energy, water, carbon and cultural and biological diversity (ICIMOD, 2018). It covers eight countries with 240 million people in the HKH Region and 1.9 billion people downstream. It is the source of ten major river systems that provide fresh water for domestic use, agriculture production and industry. The HKH Region and the rivers’ basins support some of the world’s most populated areas. Malnutrition and hunger are widespread in HKH countries. Of the approximately 800 million undernourished people globally, 415 million live in HKH countries (FAO, IFAD and WFP, 2015).

Despite the importance and serious challenges of poverty, food insecurity and natural resource degradation that mountain ecosystems and the people of the HKH Region face, decisions on mountain resources are often made outside the mountains, according to ICIMOD.

To address the challenges, the following ICIMOD programmes are being implemented in cooperation with national programmes to enhance food security, improve livelihoods and protect natural resources. These programmes include:

- ◆ Pastoralism
- ◆ Agro-pastoralism
- ◆ Middle hill farming systems

Figure 2.18 The Hindu Kush Himalayan (HKH) Region (dark blue) showing the basin of the major rivers that originate from that region



Source: ICIMOD, 2018

Figure 2.19 ICIMOD's diagram for "resilient mountain villages" to prepare for climate, socio-economic and future resilience



Source: ICIMOD, 2018

- ◆ Shifting cultivation
- ◆ Commercial crop-based systems

One example of ICIMOD's successful efforts to overcome the challenges in the HKH Region is the establishment of "resilient mountain villages" for climate, socio-economic and future resilience (Figure 2.19). Eight successful resilient mountain villages have been established in Nepal with the involvement of 1 000 households, 83 percent of which are represented by women. The pilot village scheme has now been scaled to 14 districts by the Government of Nepal (ICIMOD, 2018).

Another example of ICIMOD's achievements is in crop production, specifically intercropping of cardamom-based agroforestry on marginal lands. This has increased income, improved livelihoods of resource-poor farmers and enriched soil fertility (ICIMOD, 2018). Cardamom is a high-value, low-volume, low-input, non-nutrient exhaustive and non-perishable cash crop that is grown successfully under the nitrogen-fixing Himalayan Alder shade tree. This production system, which is not labour intensive, meets the needs of the agro-ecology of the HKH Region.

2.8 Conclusions regarding the benefits of sustainable development for mountain ecosystems and agriculture

The sustainable development of both mountain ecosystems and agriculture are interrelated. Both contribute to global food security and improve livelihoods to reduce poverty. More specifically, investment in mountain areas would:

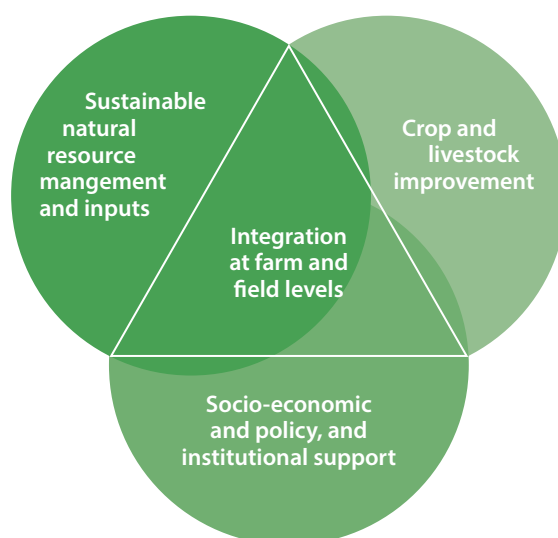
- ◆ Improve the livelihoods by reducing the poverty of about one billion people in mountain communities and those living downstream.
- ◆ Preserve and protect natural resources in mountain areas globally, which are important for more than 50 percent of the world population.
- ◆ Maintain and improve mountain environmental services and resources of global importance, specifically freshwater, biodiversity and renewable energy sources; mitigate natural hazards; control soil erosion; and ensure sources of raw material and high-quality products.
- ◆ Enhance the sustainable management of mountain areas, and the efficient use and preservation of mountain water, as the world heads towards a water crisis.
- ◆ Preserve cultural heritage and indigenous knowledge of mountain people.
- ◆ Achieve political stability and peace, which are important for sustainable development.
- ◆ Invest in tourism and recreation to improve incomes and livelihoods of mountain communities.
- ◆ Limit outmigration of mountain people and urbanization to try to preserve indigenous cultures and keep families together.
- ◆ Limit seasonal outmigration of men to lowland cities to reduce the responsibilities and pressure on mountain women.
- ◆ Build resilience and disaster preparedness to climate change through adaptation and mitigation.

2.9 Recommendations for the sustainable development of mountain agriculture

The sustainable development of mountain agriculture requires long-term investment in holistic and integrated approaches that involve policy, socio-economic and institutional aspects; natural resource management; and crop and livestock improvement (Figure 2.20). To achieve this, the following recommendations should be considered:

2.9.1 Policy, socio-economic and institutional considerations

- ◆ Develop and implement policies, strategies and programmes to address challenges, including socio-economic issues facing sustainable mountain agriculture development.
- ◆ Strengthen existing and establish new national institutions to provide public services, including extension and micro-credit to support sustainable mountain agriculture.
- ◆ Involve representatives of mountain communities in the decision-making processes.
- ◆ Develop infrastructure in mountain areas to support agricultural development.
- ◆ Increase attention to risk management and develop policies for prevention, mitigation and relief to cope with natural disasters.
- ◆ Link farmers to markets.

Figure 2.20 An integrated approach for the sustainable development of mountain agriculture

Source: El Solh, 2014

2.9.2 Financial mechanisms and economic support

- ◆ Increase levels of investment and financial support for the sustainable development of mountain agriculture at national, regional and international levels.
- ◆ Integrate sustainable development of mountain agriculture within the budget of national development strategy.
- ◆ Establish livestock communities breeding with herders and pastoralists where unproductive animals are culled to keep productive animals to improve livestock populations and herds.
- ◆ Ensure the development of integrated crop–livestock–rangeland production systems to use natural resources effectively.
- ◆ Encourage the production of high-value crops, including fruit trees, vegetables and ornamentals, and value-added products in both crop and livestock production to improve incomes and livelihoods.
- ◆ Promote protected agriculture to intensify production of high-value crops and increase water use and production efficiencies per unit area in mountain agriculture.
- ◆ Consider the implications of climate change on global warming, monitor changes in glacier status, water floods and runoff in mountain areas.
- ◆ Develop and support capacity building and extension targeting different stakeholders, including farmer programmes, to promote the sustainable development of mountain agriculture.
- ◆ Develop and implement communication programmes and audiovisual aids to promote advanced technologies and knowledge on sustainable mountain agriculture development.
- ◆ Promote and utilize International Mountain Day on 11 December to organize events and workshops that promote the sustainable development of mountain agriculture.

2.9.4 Regional and international cooperation

Different countries face similar challenges, constraints and situations in mountain agriculture, which are often complex and difficult to resolve within individual countries or institutions, for example, issues associated with trans-boundary mountain ecosystems and river basins that originate in mountain regions. Address the challenges facing mountain ecosystems and agriculture by strengthening inter-country regional and international cooperation, particularly with the FAO, Mountain Partnership, ICIMOD and other organizations.

2.9.3 Research and capacity development

- ◆ Develop research programmes in national research institutions and universities to address the challenges facing the sustainable development of mountain agriculture.

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3 The potentials of Future Smart Food for mountain agriculture achieving Zero Hunger: nutrition, climate-resilient, economic and social benefits

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3.1 Context

The prevalence of hunger and malnutrition is disproportionately higher in the mountains in Asia than in the plains and lowlands. For example, in Pakistan, food insecurity in mountain provinces is higher than the national average. Specifically, in Balochistan Province, approximately two-thirds of the population are food insecure and the prevalence of stunted, wasted and underweight children (aged below 5 years) is 82 percent, 13 percent and 37 percent, respectively, which is significantly higher than national averages in Pakistan (Adhikari, Hussain and Rasul, 2017).

In Viet Nam, the average level of undernutrition in the northern mountainous province of Lao Cai is 40 percent, almost twice the national average, and this can be attributed to local diets where rice makes up the majority of each meal (Rudert, 2015). In the Himalaya Mountains, micronutrient deficiency is widespread, with the communities there considered particularly susceptible to iodine-deficiency. Naturally occurring, water-soluble iodine is often leached from the soil by glacier action and water drainage (Andersson *et al.*, eds.).

The main reason for the high prevalence of hunger and malnutrition in the mountains is because mountain agriculture and food systems have not received the necessary attention and investment to ensure they can provide sufficient, nutritious and safe food with the necessary nutrients to meet the needs of mountain populations. Currently, mountain agriculture relies on a narrow range of food crops such as rice, wheat and maize (Schmidt *et al.*, 2010.), and this increasing trend has led to a decline in the cultivation and consumption of other crops including more traditional crops that are nutritious and climate-resilient. This trend has resulted in low production diversity and dietary diversity and,

consequently, a greater prevalence of malnutrition in the mountains (Padulosi, *et al.*, eds. 2012). For instance, consumption statistics show that the intake of neglected and underutilized species (NUS) crops in both Nepal and Pakistan is very small compared to staples. In Pakistan, rice and wheat contribute 53 percent of the per capita per day calorie intake and NUS crops while traditional crops such as millets, barley and sorghum, contribute only 0.22 percent. In Balochistan and Khyber Pakhtunkhwa, wheat and rice contribute 59 percent and 51 percent of the daily calorie intake, respectively, while NUS crops such as sorghum, barley and millets (collectively) contribute only 0.23 percent and 1.63 percent in Balochistan and Khyber Pakhtunkhwa, respectively (Hussain, 2009). In Nepal, rice, wheat and maize contribute nearly 62 percent of the daily calorie intake whereas NUS crops such as millets, barley, buckwheat, black gram and horse gram contribute only 3.84 percent to annual per capita food consumption (Adhikari, Hussain and Rasul, 2017).

Agriculture, the main source of livelihood for most of Asia's mountain populations, is the main contributor of mountain food security and nutrition. So how we transform, reorient and enable mountain agriculture to provide sufficient, nutritious and safe food for mountain populations will be essential for achieving Zero Hunger. Currently, mountain agriculture faces challenges such as fragility, inaccessibility, and marginality. In light of increasing malnutrition problems and climate uncertainty, which has triggered the demand for nutrition-sensitive and climate-smart agriculture in mountain areas, it is important invest much more in mountain agriculture systems to identify foods that can be produced in the mountains to concurrently meet nutritional needs. Such foods need to be mountain

adaptable, improve livelihoods, and empower the cultural identity of mountain people. Future Smart Foods (FSF), namely NUS that are nutrient-dense, climate-resilient, economically viable and locally available or adaptable, offer a desirable solution for sustainable mountain agriculture. Compared with staple food crops, FSFs characteristically require low inputs for high outputs (macronutrients and micronutrients), are highly nutritious, and well-adapted to the marginal and extreme climate conditions with little external input, so offering sustainable food production (FAO, FSF, 2018). FSFs have the potential to contribute to the eradication of hunger and malnutrition, and serve as a buffer in the context of ongoing climate change and they play a major role in agricultural diversification strategies by replacing crops that fail under climate change scenarios.

3.2 Future Smart Food: Concept and main features

3.2.1 The FSF concept

FSF is a term used for NUS that are nutrient-dense, climate-resilient, economically viable, and locally available or adaptable (FAO, 2018). NUS are key elements of the agrobiodiversity that is essential for sustainable agriculture. Globally, of the 300 000 to 500 000 plant species, 30 000 have been identified as edible plant species; of these, more than 7 000 crop species have been either cultivated, domesticated, or collected from the wild as food throughout the history of humanity (Garn and Leonard, 1989). However, no more than 150 crop species are cultivated commercially, with 103 of these providing up to 90 percent of the calories in the human diet. Three main crops, namely rice, maize and wheat, provide 60 percent of the world's food energy intake (FAO, 1995). This means that tens of thousands of edible plant species remain relatively "underutilized", with respect to their ability to contribute to the world's increasing food requirements (Chivenge and Mabhaudhi, 2015; FAO, 2018).

NUS offer tremendous opportunities for fighting poverty, hunger and malnutrition, as well as huge potential for achieving nutrient-dense, climate-resilient and sustainable agriculture. NUS have high nutritional value and can be an essential source of micronutrients, protein, energy and fibre, which may contribute to food and nutrition security. As well as their superior nutritional qualities, many NUS crops can be grown on marginal land, are easily intercropped or rotated with staple crops and can easily fit with integrated crop production systems. Because many NUS have the unique ability

to tolerate various stresses, they can make production systems not only more diverse but more sustainable and climate-resilient. (FAO, FSF, 2018)

3.2.2 FSF: Main features

It should be highlighted that not all NUS meet the conditions of being nutrient-dense and/or climate-resilient to foster food and nutrition security. Only those NUS that meet these four criteria qualify as Future Smart Food. The main features of Future Smart Food are four-dimensional being:








- 1 nutrient-dense (enhance nutrition);
- 2 climate-resilient (e.g., require low inputs, promote climate change resiliency, environmentally friendly by reducing runoff and erosion);
- 3 potentially economically viable (e.g., generate income and reduce female drudgery); and
- 4 locally available or adaptable (FAO, 2018).

3.2.3 FSF initiative

What is the significance of FSF for sustainable agriculture and food systems, including mountain agriculture and food systems? To date, agriculture and food systems have relied on staple crop production, which has led to two significant gaps: a) production gap – FAO projections suggest that by 2050, agricultural production must increase by 50 percent globally to meet food demand. However, increased production of staple crops, which dominate current agricultural systems, are unlikely to meet this increasing demand, as irrigated wheat, rice and maize systems appear to be near 80 percent of their yield potential, and b) the nutrition gap – the current high levels of malnutrition reflect unbalanced diets with low nutrition diversity, which is reflected in the low production diversity, as staple foods fail to provide the necessary nutrients for healthy diets (FAO, 2018). In contrast, NUS may be the key to agricultural diversification and play a significant role in narrowing and closing production and nutritional gaps. In addition, the adaptation of targeted NUS to harsh environments and low input agriculture will reduce the current pressure on natural resources.

To support countries to identify and prioritize NUS and integrate them into agricultural and food systems, the FAO Regional Office for Asia and Pacific (RAP) launched a FSF Initiative in 2016, in collaboration with a wide range of national and international partners. A regional priority-setting exercise on scoping and prioritizing was conducted by countries to identify and prioritize NUS

Table 3.1 Future Smart Food examples

Future Smart Food	Image	Nutritional and climate-resilient traits	Country
Lentil		<ul style="list-style-type: none"> ◆ Second-highest ratio of protein per calorie of any legume, after soybeans ◆ Huge potential to be grown as a winter crop in warm temperate and subtropical zones 	Bhutan, India
Buckwheat		<ul style="list-style-type: none"> ◆ Rich in iron and zinc – deficiencies of which are a major cause of hidden hunger ◆ Cultivated from alpine regions to the subtropical regions 	Bhutan
Moringa		<ul style="list-style-type: none"> ◆ Significant source of vitamins, manganese, iron and protein ◆ Rich in calcium, potassium, vitamin A, vitamin C and protein ◆ Powerful anti-inflammatory and antioxidant properties ◆ Popular vegetable with medicinal value Fast growing and drought resistant 	Bhutan, Cambodia, India, Lao PDR, Myanmar, Nepal, Viet Nam
Mung bean		<ul style="list-style-type: none"> ◆ High in protein, resistant starch and dietary fibre ◆ Short growing cycle, increased adaptability, drought tolerant 	Bangladesh, Nepal and Viet Nam
Taro		<ul style="list-style-type: none"> ◆ Rich in carbohydrates and high levels of calcium and vitamin A ◆ Cultivable in a wide range of areas; multipurpose vegetable with high market value 	Bangladesh, Cambodia, India, Lao PDR, Nepal and Viet Nam
Quinoa		<ul style="list-style-type: none"> ◆ Rich in fibre, antioxidants, protein, iron and zinc ◆ Climate resilient; adapts well to various altitudes 	Bhutan, Lao DPR and Nepal
Foxtail millet		<ul style="list-style-type: none"> ◆ Helps to control blood sugar levels and reduces the risk of heart attack ◆ Climate-resilient crop; grows in a wide range of agro-climatic conditions ◆ Suitable for cultivation in marginal soils of char land 	Bangladesh and India

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based on the four criteria to qualify as FSF. Consequently, 39 FSFs were selected and prioritized by eight countries. The integration and promotion of FSFs offer a promising future for transforming the current agricultural system to be more sustainable, nutrition-sensitive and climate-resilient (FAO, 2018) Table 3.1 lists some examples of prioritized FSFs that can be grown in the mountains.

3.3 Future Smart Food: comparative advantages for mountain agriculture development achieving Zero Hunger

3.3.1 Nutrition dense – mountain hunger and malnutrition

One of the outstanding features of FSF is that they are nutritious, and often higher in macronutrients (e.g. protein and fats) and micronutrients (e.g. vitamins, minerals) than staple foods for mountain populations, deficiencies of which lead to stunting, wasting and being underweight. This section provides some examples of FSFs that are suitable to grow in the mountains and demonstrate their remarkable nutritional qualities.

Pulses have been prioritized as FSFs by many countries in Asia, including Cambodia, India, Myanmar, Nepal and Viet Nam. Pulses are rich in protein, nutrients and dietary fibres that are important for a healthy diet and can help to reduce the risk of developing several chronic non-communicable diseases. Pulses include chickpea, cowpea, lupine, field pea, common bean, lentil, mung bean, pigeon pea, faba beans and others. For example, chickpea in comparison with white polished rice contains three times more protein, four times more dietary fibre, four times more iron, and 70 times more folate, though the energy level is similar in both crops. Similarly, lupine contains five times more protein, eight times more dietary fibre, four times more iron, and 44 times more folate than rice. These FSFs are well adaptable to the agroecosystems of mountains.

Cowpea (*Vigna unguiculata*) is an FSF prioritized by Viet Nam and Cambodia, among others. It contains 25 percent protein and several vitamins and minerals: cowpea has significant potential to contribute to food and nutrition security by providing vitamins and minerals when consumed as a leafy vegetable, and protein when consumed as a grain legume (Modi and Mafongoya, 2015). It is not only a protein-rich legume that complements in amino acids and other nutrients

staple cereal and starchy tuber crops, but it also provides fodder for livestock, soil improvement benefits through nitrogen fixation, and household benefits in the form of cash and income diversity. It thrives in arid and semi-arid tropics covering Africa, Asia, Europe, the United States, and Central and South America (CGIAR, 2019).

Taro (*Colocasia esculenta* (L.) Schott) is an FSF prioritized by Nepal, Bangladesh, Cambodia and Viet Nam, among others. It is a rich source of carbohydrate, vitamins A and C, and protein. Leaves and corms of taro are edible and also serve as a leafy vegetable supplying mineral nutrients to the traditional diets of smallholder farmers. Taro features in several agroforestry systems as it is shade tolerant, making it ideal for mixed cropping systems, which typically feature trees (Modi and Mafongoya, 2015).

Millet, prioritized as a FSF by most South Asian countries including Bangladesh, Bhutan and India, are often referred to as a “high-energy” cereals as their protein and vitamin A contents are higher than maize, and their oil content is higher than maize grains. Millets contain vitamin A – a major deficiency in staple diets – which makes it a suitable crop for combating nutritional challenges in mountain communities (Modi and Mafongoya, 2015). Table 3.2 illustrates the difference between the nutritional value of selected millets and staple crops. For instance, pearl millet has higher micronutrient (such as calcium, iron, zinc, riboflavin and folic acid) contents than rice or maize, and higher micronutrient (excluding calcium) contents than wheat. (Adhikari, Hussain and Rasul, 2017)

FSFs, by definition, also include wild food species such as indigenous fruit trees, indigenous leafy vegetables, and wild plant and animal species which are nutritious (Biodiversity International, 2017). For instance, mushrooms are low in calories, fat and sodium, high in protein and fibre, and contain many important vitamins and minerals. Most mushrooms usually contain around 20–30 percent protein by dry weight, along with vitamin D, niacin and vitamin B, and high levels of selenium, potassium, phosphorous, zinc and magnesium. Selenium is an antioxidant that helps to neutralize free radicals preventing cell damage and reducing the risk of cancer and other diseases. Potassium is an extremely important mineral that regulates blood pressure and keeps cells functioning properly. A large portobello mushroom is said to have more potassium than a banana. (Mushroom Appreciation, 2019)

Table 3.2 Comparison of nutritional value between selected millets and staple crops

Nutrient	Selected millets (100 g)							Staple food (100 g)		
	Pearl Millet	Sorghum	Finger Millet	Foxtail Millet	Proso Millet	Barnyard Millet	Kodo Millet	Rice (Milled)	Maize	Wheat Flour
Energy (kcal)	361.00	349.00	328.00	331.00	341.00	397.00	309.00	345.00	342.00	346.00
Protein (g)	11.60	10.40	7.30	12.30	7.70	6.20	8.30	6.80	11.10	12.10
Fat (g)	5.00	1.90	1.30	4.30	4.70	2.20	1.40	0.40	3.60	1.70
Calcium (mg)	42.00	25.00	344.00	31.00	17.00	20.00	27.00	10.00	10.00	48.00
Iron (mg)	8.00	4.10	3.90	2.80	9.30	5.00	0.50	3.20	2.30	4.90
Zinc (mg)	3.10	1.60	2.30	2.40	3.70	3.00	0.70	1.40	2.80	2.20
Thiamine (mg)	0.33	0.37	0.42	0.59	0.21	0.33	0.33	0.06	0.42	0.49
Riboflavin (mg)	0.25	0.13	0.19	0.11	0.01	0.10	0.09	0.06	0.10	0.17
Folic acid (mg)	45.50	20.00	18.30	15.00	9.00	–	23.10	8.00	20.00	36.60
Fibre (g)	1.20	1.60	3.60	8.00	7.60	9.80	9.00	0.20	2.70	1.20

Source: National Institute of Nutrition, India

3.3.2 Climate-resilient – mountain adaptability

FSFs can help agriculture production to adapt to climate change by enhancing the diversification and resilience of agroecosystems to withstand the impacts of climate change implications (e.g. drought, cold, global warming and the increased frequency and intensity of extreme weather events). Unlike rice and wheat that require many inputs in terms of fertilizer and irrigated water, FSF are adapted to low-input agriculture and can grow in upland or marginal lands where staple crops can hardly grow.

With regard to drought resistance, FSFs such as pulses and millets can be well integrated into farming systems. During the dry season, most highlands are left fallow after harvesting the main crops. However, FSFs that are drought-tolerant can grow on residual moisture after harvesting crops grown in the rainy season or under drip irrigation, combined with integrated farming practices such as intercropping and relayed cropping, which can utilize fallow land for planting forages, as well as the main crops and other high-value crops. For instance, India has actively integrated pulses into rice fallow on a large scale. The selection of crops and varieties with early maturity, different root architecture (i.e. longer and finer roots, more root tips, greater branching angle, and lower shoot:root ratios) and *in situ* moisture conservation practices (e.g. ridging, mulching) may help to minimize irrigation requirements during dry periods (Chapagain and Raizada, 2017).

Mungbean (*Vigna radiata* var. *radiata*) is an FSF prioritized by Nepal and a relatively important short-season legume crop in Asia. Mungbean is a good source of dietary protein with high contents of folate and iron compared with many other legume crops (Keatinge, *et al.*, 2011). As a short-duration legume, mungbean fits well into the fallow period between rice–rice, rice–wheat, rice–potato–wheat, maize–wheat, cotton, and other cash crop cropping systems. Planting mungbean improves soil fertility and provides additional nitrogen to subsequent crops. The yield of rice following a mungbean intercrop can increase by up to 8 percent through the nitrogen fixed by mungbean in the soil and reduced pest and disease pressure compared to cereal mono-cropping (Ebert, 2014).

Millets which include different genotypes are known for their drought tolerance and grow well in dry zones as rainfed crops under harsh climates and marginal conditions of soil fertility and moisture. Millets can grow on a wide variety of soils ranging from clay loams to deep sands, but the best soil for cultivation is deep and well-drained soils. This makes it suitable for cultivation by smallholder farmers in semi-arid areas where deep sands and sandy loam soils dominate. In addition, millets are easy to cultivate and can be grown in arid and semi-arid regions where water is a limiting factor for crop growth (Modi and Mafongoya, 2015). Commonly grown millets are sorghum (*Sorghum bicolor*), pearl millet (*Pennisetum glaucum*), finger millet (*Eleusine coracana*), barnyard millet (*Echinochloa crus-galli*), foxtail millet

(*Setaria italica*), kodo millet (*Paspalum scrobiculatum*), proso millet (*Panicum miliaceum*) and little millet (*Panicum sumatrense*), (Bose, 2018). For instance, minor millets which include six grain crops namely finger millet, foxtail millet, kodo millet, proso millet, barnyard millet and little millet (*Panicum sumatrense*), have a short biological cycle and efficient root systems that offer a comparative advantage where water is scarce and rainfall is low (Padulosi *et al.*, 2009). In addition, minor millets offer modest yields from marginal/poor soils with low inputs, which has made them important in mountain and hill agriculture (Padulosi *et al.*, 2011). Minor millets are used particularly in South Asia where their drought-resistant traits coupled with an excellent nutritious profile offer major opportunities for the development of areas increasingly affected by water shortages, such as those in the marginal hills of Tamil Nadu or Karnataka States of India (Bala Ravi 2004; Padulosi *et al.*, 2009).

Moringa (*Moringa oleifera*) is an FSF prioritized by Bhutan, Myanmar, Nepal and other countries in Asia. It is drought resistant with high nutrient density and famous as the “wonder tree”. Moringa is a fast-growing tree that adapts well to hot, semi-arid regions in the tropics with as little as 500 mm annual rainfall (Yang, 2006), and can adapt to altitudes above 2 000 m. It also tolerates occasional wet or waterlogged conditions for short durations, but prolonged flooding leads to a significant loss of plants (Ebert, 2014). It is rich in many essential micronutrients and vitamins as well as antioxidants and bioavailable iron. It excelled among 120 species of traditional Asian vegetables tested for their micronutrient and phytochemical contents, antioxidant activity (AOA), and traditional knowledge of medicinal uses (Yang, *et al.*, 2006). Moreover, it is easy to grow, has excellent processing properties, and good palatability (Padulosi *et al.*, 2011). Boiled fresh moringa leaves and dried powder in water enhanced the aqueous AOA and increased bioavailable iron by 3.5 and 3 times, respectively (Yang *et al.*, 2006).

Quinoa (*Chenopodium quinoa*) was first farmed by the Incas in the mountains of Bolivia, Chile and Peru. It has high nutritional value that not only survives but thrives in marginal areas due to its high adaptability. It is a high-altitude plant, growing at 3 600 m above sea level and higher, where oxygen is thin, water is scarce, and the soil is more saline. Recently, experimental cultivation of quinoa in saline and marginal soils of Pakistan has shown that this crop can produce respectable yields in stressful conditions (Padulosi, *et al.*, 2015).

Buckwheat (*Fagopyrum esculentum*) is an FSF prioritized by Nepal and Viet Nam, among others. It is commonly grown in the Himalayan region, as it grows fast and suppresses weeds. It also boasts great resistance to cold weather conditions. Barley (*Hordeum vulgare*) is another good example of a FSF as it tolerates water stress and extremely cold conditions. With its short growing period, barley is often cultivated in the high altitudes and cold climate of the Tibetan Plateau, China and the Gatlang area of the Rasuwa district, Nepal (Adhikari, Hussain and Rasul, 2017). Barley is also easily cultivated in arid and semi-arid areas of temperate regions with only 250 mm of rain only.

3.3.3 Economically viable – mountain livelihood

FSFs provide income opportunities for the mountain poor. They can contribute to the improvement of livelihoods in mountain populations based on their higher nutritional and health value as well as the fact that many are off-season crops. Being organic, such crops are also seen as safer or healthier. This is in addition to their adaptation to low input agriculture which will reduce the pressure on natural resource degradation. Several studies and projects have highlighted the consistent contribution of NUS to generating income in both domestic and international markets (Asaha *et al.*, 2000; Mwangi and Kimathi 2006; Chadha and Oluoch 2007; Joordan *et al.*, 2007; Rojas *et al.*, 2009). In India, for example, adding value to little millet enhanced farmer incomes three-fold and generated employment in villages, particularly for women, which enhanced women's social status and self-esteem (Vijayalakshmi *et al.*, 2010).

Many previous indigenous NUS are globally well-known crops, such as oil palm and kiwi, which have the potential to contribute to food security and nutrition, dietary and production diversity, health improvement and income generation. Both of these crops became commercially of economic importance globally. Quinoa is another good example of a FSF that is becoming globally known with high economic benefits for mountain people. Quinoa has attracted increasing attention from the world, particularly after the International Year of Quinoa in 2013, which resulted in increasing global demand for the product. For instance, Bolivia has emerged as a bright spot in its region, posting an average annual growth rate of 5 percent for quinoa from 2005 to 2014, with a outstanding 6.8 percent in 2013. Farmers who had once struggled to

make ends meet are now earning substantial revenue from quinoa cultivation. Similarly, Peru has become one of the world's leading producers of quinoa. Peruvian quinoa exports have increased almost ten-fold since 2010, growing from USD 15 million in 2010 to USD 143 million in 2015 (Bellemare, *et al.*, 2016). Improvements in living conditions have subsequently improved livelihoods and education for mountain people in the Andes.

Some FSFs have high medical importance. For instance, drumstick has excellent medicinal properties – the leaves have a stabilizing effect on blood pressure and control glucose levels, and are useful for treating night blindness as they are a rich source of vitamin A. Drumstick is also used to treat anxiety, diarrhea and inflammation of the colon, skin infections and scurvy. The leaves contain an ethanol derivative that can offer relief to individuals suffering from gastrointestinal disorders (Dandin, 2014). Many other wild plants show strong medicinal value, such as the rare White *Garcinia* fruit, found in forests in southern India, which is highly valued in Ayurvedic medicine to treat severe gastric reflux. In the Pamir Mountains, safflower, purslane, black cumin, sea buckthorn and wild rose, among others, are used to treat common ailments (Kennedy, *et al.*, 2017). The traditional medicinal value of plants can be further translated into high market value as a strategy to alleviate poverty. In China, traditional Chinese medicine is a system science guided by Chinese medicinal theories and relies heavily on the availability of high-quality medicinal plants. The health and medicinal value of a specific plant, often grown in the mountains, varies significantly according to where it is grown, climatic conditions, soil type, use of fertilizers or pesticides, and when and how it is harvested and processed. Traditional medicinal plants with special origins are recognized as *Dao Di Yao Cai*, which have a high reputation in traditional Chinese medicine. For instance, Lei Gong Mountain – located in the Guizhou province of China at an altitude of 480–2 179 m and average temperature of 14–15°C – is a plant hub for traditional Chinese medicinal that produces 1 305 species of medicinal plants from 206 families and 669 genera, including endangered and precious Chinese traditional medicinal plants, such as Du Zhong/*Eucommia ulmoides* (*Eucommiae cortex*), Tian Ma/Tall Gastrodiae (*Gastrodieae rhizoma*) and Hou Pu (*Magnolia officinalis*) (Qi, 2014). Traditional Chinese medicines, processed using these traditional medicinal plants in Lei Gong Mountain, are well-known in the traditional Chinese medicine market.

FSFs growing in the mountains, with minimal fertilizer or pesticides and often considered organic, have higher market value as niche products. For instance, in India's Central Himalayan Region, women farmers are knowledgeable about many traditional agricultural practices that use no chemical inputs. Organized by agricultural microenterprises, 2 800 women farmers have increased supply and capitalized on the growing demand for organic products. Eighteen different types of traditional crops are marketed in Indian cities, including buckwheat, horse gram and foxtail millet. Recognizing its high quality, a Japanese company is purchasing foxtail millet in bulk for the preparation of baby foods (Khalid and Kaushik, n.d).

3.3.4 Locally available or adaptable – mountain traditional knowledge

Expounders of FSFs recognize that they can help to preserve traditional mountain knowledge and the cultural identities of indigenous mountain people. Being locally available or adaptable is an important feature of FSFs that can contribute to sustainable mountain agriculture development. Thanks to the indigenous people who acquired the capacity to conserve and manage natural and agricultural ecosystems, many traditional food systems have healthy elements based on local crop species having high nutritional values and are well adapted to climate change implications. Consequently, many FSF species and varieties have excellent desirable traits to both survive and thrive in difficult conditions, especially mountain areas.

Traditional farmers have domesticated, improved and conserved thousands of crop species and varieties over hundreds of years. They recognize that crop success is subject to variability and the unpredictability of weather conditions and occurrence of diseases and insect pests. This precious traditional knowledge is acquired through frequent interactions with the local environment, driven by the need to pursue subsistence strategies for food and economic provision, and is often transmitted within communities. Abundant evidence shows that indigenous people have, over the years, acquired traditional knowledge in the selection of traditional crop varieties and new varieties/landraces that could adapt more easily to climate change. For instance, there is a dependence on finger millet in Northern India; as the rainfall has declined to 300 mm in recent years across the region, the finger millet varieties grown and conserved by farmers have shown excellent drought resistance

Figure 3.1 Development stages of food systems for Future Smart Food

and have therefore remained unchanged. This suggests that these varieties have sufficient adaptability to enable farmers to cope with periods of significant rainfall shortages (Modi and Mafongoya, 2015).

As mountain traditional knowledge associated with FSFs is often undocumented or hidden due to the isolation of mountainous areas and language barriers, there is a need to proactively tap into this knowledge to understand the various traits of local FSF species and varieties. This means they can be improved and further adapted to local farming systems in mountains. Meanwhile, building knowledge about traditional FSF crops should encourage local landrace conservation and production, local seed fairs, community seed banks, and community-based conservation and adaptation in mountains regions (Modi and Mafongoya, 2015).

Moreover, it is recognized that traditional food systems in mountain areas are very much intertwined with the cultural identity of the indigenous people. They understand the local ecosystems and have built up a store of knowledge that has passed from generation to generation. It is this knowledge that will help protect and conserve mountain ecosystems so that these traditional food systems can empower mountain indigenous people and help improve their livelihoods.

3.4 Harnessing the potential of Future Smart Foods for mountain agriculture development

From a food system perspective, transformation of mountain agriculture and food systems to become more diversified, nutrition-sensitive, climate-resilient, economically viable and locally adaptable is needed. FSFs can play a significant role in transforming these systems if they are mainstreamed.

To tap into the opportunities that FSFs offer for achieving Zero Hunger and poverty reduction in mountain areas, focus is needed on the identification and prioritization of NUS that can be potentially become FSFs with local mountain specialty in terms of production, post-harvest and processing, marketing and consumption, and links to markets (Figure 3.1). Overall, the emphasis should be on building capacity for

mountain FSF products at each development stage of the food system, i.e. prioritization, production, post-harvest and processing, marketing and consumption, and connecting all stages of the food system to minimize transaction costs.

To harness the potential of FSFs in mountain regions, it is important to establish an enabling environment that promotes diversified, nutrition-sensitive, climate-resilient, economically viable mountain agriculture and food systems through the identification, production, processing, marketing and consumption of FSFs with mountain specialties, linked to urban food systems. Government leadership is needed when it comes to building an enabling environment for mountain FSFs for mountain agriculture development. To unlock the hidden potential of FSFs and support the development of mountain agriculture, the role of the government is indispensable. Policies for mountain farmers need to be embedded in an overall policy of regional mountain development, covering all stages of FSF development. A holistic food systems approach for mountain FSF is as follows:

- 1 **Prioritization:** identify and prioritize NUS to be potentially FSFs with mountain specialty.
- 2 **Production:** increase production of targeted mountain FSFs in mountain farming systems adaptable to various agro-ecological zones.
- 3 **Processing:** improve the efficiency of post-harvest and processing of FSFs mountain specialty product.
- 4 **Marketing:** promote the distribution and marketing of FSFs as mountain specialty product..
- 5 **Consumption:** Increase the demand for FSFs as mountain specialty product among consumers by increasing awareness and knowledge on their multi-dimensional benefits including nutritional value.

Prioritize FSFs with mountain specialty

Identify FSFs with mountain specialty by following the established four-dimensional criteria to ensure sustainability: 1) nutrient dense, 2) climate-resilient, 3) economically viable and 4) locally available or adaptable. By doing so, mountain communities could produce sufficient, nutritious and safe FSFs for

themselves and gain the economic benefits of marketing surplus agricultural produce and services, while promoting conservation and the sustainable use of biodiversity, and ensuring environmental sustainability.

Increase production of FSFs with mountain specialty

To increase production of FSFs as mountain specialty product, it is important to conduct research and development on FSFs, especially the development of improved varieties of FSFs. The improved varieties need to be integrated into various mountain farming systems and adapted to local agro-ecological zones in the mountain areas. Meanwhile, it is important to build the capacity of smallholder farmers in the mountains to grow FSFs so that they have surplus FSFs for household consumption and extra to sell to markets. Part of improving capacities is to improve production efficiencies by optimizing the use of resources while maximizing the output. This can sustain production and potentially make FSFs more affordable to consumers.

Processing FSFs with mountain specialty

Processing FSFs as mountain specialty products is the transformation of agricultural products into food, or of one form of food into other forms. Food processing includes many forms of processing foods, from grinding grain, to make raw flour to home cooking, to making jams and pickles to complex industrial methods used to make convenience foods for direct consumption. It includes post-harvest, processing, packaging and labeling to make the FSFs more convenient, accessible and informative with nutritional panels as special mountain products. These activities result in value-added produce that can reduce food losses along the value chain, and enhance smallholder farmers' income.

Marketing: upgrade market chains

The process of introducing new products to the market connects production, processing, distribution, marketing and consumption. Good marketing should cover advertising, promotion, public relations and connection to market channels. Due to the physical isolation and limited resources of mountain communities, who are severely affected by low levels of education, there is limited knowledge and information on how to market products. Policy makers, especially local governments, should play a proactive role in the coordination of stakeholders to help indigenous people to develop market-oriented strategies for the sustainable development of FSFs, including market expansion of FSFs through fair trade and mountain product

promotion. Advanced technical means could be used, including e-commerce, to overcome the barriers of geographical isolation for the promotion of FSF mountain products.

Increase demand for FSFs with mountain specialty

Increasing the demand for FSFs could be the driver for transforming agriculture and food systems, which will benefit consumers, smallholder farmers and other value chain actors. The demand for FSFs can be increased by increasing consumer and smallholder farmer awareness about the multi-dimensional benefits of consuming FSFs. This requires more information on the nutrients of FSFs, the preparation of FSF crops, and techniques to access the population through processing and other value additions. Establishing trusted brands and changing consumer perception towards FSFs is vital at all stages of the process to bring FSF mountain products to markets. Current research findings and knowledge on FSF needs to be disseminated through various media, local agencies, newsletters and advertisements to promote the consumption of FSFs.

3.5 Conclusion

In an increasingly globalized and interdependent world, eradicating hunger and malnutrition remains a priority of the sustainable development goals. Recognizing the multifaceted challenges that mountain agriculture is facing given the fragility, inaccessibility and marginality of mountain regions, the contribution of mountain agriculture for Zero Hunger lies in its capacity to produce sufficient, nutritious and safe food from mountain areas. Harnessing the potential of mountain land that is suitable for agriculture production and which can sustainably produce sufficient, nutritious and safe food from mountains for Zero Hunger is key. FSFs offer huge potential for mountain agriculture development to achieve Zero Hunger. The main multi-dimensional benefits that FSFs with mountain specialty are: (1) nutrient dense, rich in macronutrients and micronutrients, relative to the staple food crops of mountain populations; (2) climate resilient for climate change adaptability in the mountains, to enhance diversification and resilience of agroecosystems and the ability to grow on marginal land withstanding the impact of climate change scenarios (e.g. drought, cold, increased frequency and intensity of extreme weather events); (3) economically viable, providing income opportunities for mountain populations and contributing to mountain livelihood improvement based on their higher nutritional and health value, higher level

of safety being organic, or as off-season products; (4) locally available or adaptable, and therefore recognizing mountain traditional knowledge and the cultural identity of indigenous mountain people.

Many FSF species and varieties have excellent traits to both survive and thrive under difficult conditions, especially in mountain areas. From a food system perspective, transforming mountain agriculture and food systems to be more diversified, nutrition-sensitive, climate-resilient, economically viable and

locally-adaptable system is the key to harnessing the potential of FSFs, particularly if they can be mainstreamed. To tap into the opportunities that FSFs offer for mountain agriculture achieving Zero Hunger, focus should be given to identifying and prioritizing FSFs with local mountain specialties in terms of production, post-harvest and processing, marketing and consumption that are linked to urban food systems. Government leadership will be indispensable to achieving this end.

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4 Integrated farming systems development for mountain agriculture in Asia

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4.1 Introduction

Mountains regions, despite their peculiarity, environmental sensitivity and inaccessibility are hugely significant for the global sustainability as nearly 70 percent of the world's population depends on the mountains as a supply of freshwater; sources of renewable energy and rich biodiversity. In addition, mountain agriculture and farming systems constitute the principal source of food and livelihood for about half a billion people (ICIMOD, 2010; UNEP-WCMC, 2012). In addition, indigenous communities who have adapted to living in mountain regions over thousands of years, have evolved a diversity of cultures that comprise traditional resource development and environmental conservation practices. Such communities have also developed a variety of farming and food systems that can be adapted to cope with environmental changes, and a range of institutions that have immense relevance and practical significance in ensuring food and livelihood security for large part of the world (Sonesson and Messerli, 2002). However, mountains have long been marginalized from the point of view of the sustainable development of natural resources and the wellbeing of their inhabitants.

Expert understanding about the problems of mountain regions and approach to their development has undergone drastic changes during the recent years. This has been achieved as a result of the rising awareness of the impact of environmental changes on mountain ecosystems and communities, and their serious consequences for the rest of the world which has helped draw global attention to mountains in international development discourse (ICIMOD, 2010; United Nations, 2012; Haigh *et al.*, 2002, Tiwari 2000).

Currently, mountain ecosystems as well as mountain communities are threatened by the ongoing processes of rapid environmental changes, migration and population dynamics as well as the globalizing economy, urbanization and resultant exploitation of natural

resources (Sonesson and Messerli, 2002). According to World Bank estimates, between 47 and 83 percent of populations in high mountain areas of Asia are poor with 17 to 36 percent of these populations living in absolute poverty (World Bank, 2016). It has been observed that the proportion of poor and vulnerable people increases with elevation, and the the ongoing process of globalization seems to have further increased the poverty imbalance between highlands and lowlands (Huddleston and Ataman, 2003). Furthermore, it has been estimated that a large proportion of the world's food insecure population live in mountains, and nearly 245 million rural people living in the world's mountains were vulnerable to food insecurity, with around 50 percent experiencing chronic hunger specifically in Asia and Latin America (Huddleston *et al.*, 2003; Food and Agriculture Organization, 2008).

Further problems for mountain systems which are already under stress, come from, climate change. The warming climate is affecting mountains through higher mean annual temperatures, the melting of glaciers and snow, altered precipitation patterns and hydrological disruptions as well as more frequent weather extremes (Leitner and Mojaisky, 2014).

4.2 The principal mountains of Asia

Asia is not only the world's largest continent, but is the most physiographically heterogeneous and climatically complex. Asia is home to the highest and largest of the world's mountain ranges as well as wet and dry desert climates, large river basins and huge populations supported by a huge array of agricultural systems. The Himalayan range is Asia's highest and biggest range as well as being the youngest Asian mountain range and its most densely populated. Beyond the Himalayan range is the Tibetan Plateau which is the world's most extensive inhabited land area above 2 500 metres elevation.

Important but comparatively smaller mountain systems are also found across Asia. More than a third of the mountains of the continent are covered by forest and extensive rangelands. The mountain regions of Asia are broadly divided up into: (1) Hindu Kush Himalaya; (2) Highlands of Central Asia; (3) Plateau of Tibet and Magnolia; and (4) Uplands of Southeast Asia.

The Hindu Kush Himalayan (HKH) region extends 3 500 km over all or part of eight countries: Afghanistan, Bangladesh, Bhutan, China, India, Myanmar, Nepal, and Pakistan. The range stretches from Afghanistan in the west to Myanmar in the east. The Hindu Kush Himalaya constitutes the source of ten large Asian river systems including the Amu Darya, the Indus, the Ganges, the Brahmaputra, the Irrawaddy, the Salween, the Mekong, the Yangtze, the Yellow and the Tarim Rivers. The basins of these rivers provide freshwater to 1.3 billion people – nearly a fifth of the world's population – living both in upstream and downstream areas of South, East and Southeast Asia (ICIMOD, 2010). It represents one of the geographically complex, culturally diverse, and economically underdeveloped and densely populated mountain ecosystems in the world. However, during the recent years, a variety of changes have emerged in the traditional resource use structure in HKH, mainly in response to increased population growth and rapid urbanization (Heath *et al.*, 2018; Patra and Kantariya, 2014). As a result, HKH is going through a worrying process of land use intensifications, rapid environmental changes, depletion of natural resources leading to ecological imbalance and socio-economic unsustainability both in mountains and lowland areas (Campbell, 2008; Tiwari, 2000).

The Central Asia Highlands constitute the great belt of mountains and plateaus between Hindu Kush Himalaya in the south and lowlands of Siberia in the north. In Central Asia, the chains of mountains originate from the plateau of Pamir in different directions. More than 10 percent of the area in Central Asia is covered with mountains. The main mountain systems of Central Asia include Pamir-Altai and Tien Shan which extend over an area of 3 882 000 km² in the Republic of Kazakhstan, Kyrgyz Republic, Republic of Tajikistan, Turkmenistan and the Republic of Uzbekistan with a population of over 53 million (Huddleston *et al.*, 2003). The mountain and highland ecosystems of Central Asia offer habitats for a variety of cultivated plants and animal breeds and globally important species of flora and fauna. The plateau of Tibet enclosed by the Himalayan mountains and Kunlun ranges is the largest and highest plateau of the world (Huddleston *et al.*, 2003).

The Uplands of the East and Southeast Asia are interspersed with broad lowlands associated with large rivers including the Mekong, Irrawaddy, Red, and Chao Rivers; and covered by hills, small mountains and plateau situated mainly in Thailand, Myanmar, Lao PDR and Viet Nam. The hills are characterized with undulating terrain and gentle to moderate slopes whereas the mountain areas have a high to very high surface gradient and are generally covered with forests. Most of the upland areas have a tropical and sub-tropical humid climate with tropical rainforest as the major form of natural vegetation. Most of the uplands in East and South East Asia are sparsely populated with a large number of communities practicing Swidden agriculture (slash-and-burn) (Huddleston *et al.*, 2003).

4.3 Principal mountain farming systems of Asia

The pattern and characteristics of mountain agriculture are determined and shaped by a set of complex and interconnected specificities that include, inaccessibility, fragility, marginality, diversity, niche and human adaptation mechanism to these conditions (Jodha, 2005). These typical characteristics present a range of opportunities as well as constraints to farming systems in mountains, and also influence human responses to them (Jodha, 1997 and 2005). Diversity in mountain agriculture is the product of interactions between various physical parameters and anthropogenic elements. This integrates the spatial structure of production processes and consumption patterns and requires territorial diagnosis followed by diversified interventions and decentralized arrangements (technologies, infrastructure, and institutions).

This complex and integrated agricultural system has not only contributed to environmental sustainability, but also to food, nutrition and livelihood security for poor mountain communities for thousands of years (Maithani, 1996). Integrated farming is a comprehensive term used to describe an interconnected land, forest, water, biodiversity and livestock based production system governed by a set of local institutions (Choudhary, 2013; Tiwari and Joshi, 2015; Taneja, 2016). It refers to agricultural and food systems that integrate crop production, livestock and other locally suited farm enterprises and conservation practices (Behera *et al.*, 2004). Mountain farming is complex and diverse systems are created by multiplicity of agro-ecological conditions. The integrated farming has been a traditional production system since time immemorial; but in recent years it has been elaborated

as all-round development of agriculture, animal husbandry, horticulture, fisheries and other local farm occupations. This integrated farming system is an economically and environmentally sound diversified production system (Behera *et al.*, 2004). It signifies optimization of various farm components and their integration for multi-enterprise farming systems in given set of agro-ecological regime to ensure resource use efficiencies, higher productivity and profitability (Choudhary, 2013).

In Asia, traditional mountain agriculture is a highly diverse and interdependent farming system covering all land based activities such as agronomic or field crops, horticulture, animal husbandry, poultry and fishery as well as a variety of conservation practices owing to their organic and functional linkages (Everard *et al.*, 2018). The sharp topographic variations, and climatic complexities along three dimensional mountain landscape from low lying valleys to higher elevations create diversity in agro-ecological systems, resulting in a range of farming and food production systems all across the mountain regions of Asia. At lower altitudes, intensive mixed farming systems are generally the most common form of agriculture production, whereas, at higher elevations pastoralism with seasonal transhumance is a widespread livelihood option as the rising altitude, decreasing temperature and steeper slopes limit the carrying capacity of natural resources (Huddleston and Ataman, 2003).

Over many generations, mountain communities have developed these diverse and complex farming systems for the optimal production of food and conservation of land, water and forest resources in which no input from outside the system is required (Pandey *et al.*, 2017). Mountain farming systems integrate land, forest and livestock resources ensuring a complex, diversified and interdependent production system consisting of crop husbandry, animal husbandry and conservation of bio-physical resources (Tiwari and Joshi, 2012a and 2012b; 2013, 2014 and 2018a and 2018b). In Asia, the mountain farming system consists of three components as a source of livelihoods: (1) forest; (2) farmland; and (3) livestock/pasture systems. The mountain farmers have evolved farming systems where each component takes into account the diversity of the terrain and the complexity of climatic phenomena. The farming system is sustained with organic matter and nutrients that originate from the forests and rangelands (Pandey *et al.*, 2017). These traditional agricultural systems have contributed significantly not only towards preserving the high value genetic resources of plants and animals, but have also ensured food, livelihood and nutrition security

for mountain communities for centuries (Ramakrishnan, 1992). The system offers a vast repository of a large variety of crop cultivars adapted to diverse natural as well as sociocultural traits of the region has and contributed significantly towards maintaining the diverse farming systems, cropping systems, crop diversity and genetic variability within species (Bahera *et al.*, 2004; Yadav *et al.*, 2001). The principal mountain farming systems of Asia are as follows:

4.3.1 Himalayan farming systems: (Bangladesh, Bhutan, India, Myanmar, Nepal and Pakistan)

Mountain farmer in these nations are known for their use of the Highland Mixed Farming System with animal husbandry being practiced alongside traditional crop cultivation. This represents one of the most significant mountain farming systems, and constitutes the source of food and livelihood for the nearly 48 million rural mountain people who inhabit these regions (Huddleston *et al.*, 2003). The Himalayan region is home to one of the most complex, diverse and integrated farming systems in the world (Jodha, 1997; Aase *et al.*, 2013). The nature of the terrain and climate impose severe limitations on the scale of resource productivity as well as on the efficiency of infrastructural facilities (Jodha, 2005; Maithani, 1996). As a result, forest based subsistence agriculture constitutes main source of rural food and livelihood for more than 75 percent of the population even though the availability of arable land is severely limited, agricultural productivity is considerably low, and the majority of land holding sizes are less than 1 ha (Nangju, 2001; Papola, 1998; Tiwai and Joshi, 2018a). The forests, livestock and arable land make up the three basic components of the Himalayan agro-ecosystem, in which forests are pivotal to the maintenance of crop production levels (Tiwari and Joshi, 2012a and 2012b; ICIMOD, 2010). In order to preserve soil fertility levels and the productivity of land under sustained cropping in such an agro-ecosystem, there must be a net transfer of energy from the forests to arable land (Singh *et al.*, 1984; Rasul *et al.*, 2018). This flow of energy from forest to cultivated land in the Himalayan agro-ecosystem is mediated through livestock, which is usually in the form of fodder of stall-fed cattle whose manure and labour are then applied to the cultivated land. On average, one unit of agronomic production in the region involves nine units of energy from the surrounding forest ecosystem (Singh *et al.*, 1984). Due to the constraints of the subsistence economy, the intensity of cropping is as high as 168 percent (Pant, 2000), and a large proportion of rural youth-male population out-migrates the region in search of better livelihood opportunities (Maithani, 1996).

In the Himalayan region, traditionally agricultural activities are concentrated in the valleys and mid-slopes located between 500–3000 m elevations above sea level. And Himalayan agriculture can be divided up into following three sub-farming systems:

4.3.1.1 Mixed crop livestock farming systems

This is the most common and widely practiced agricultural system across the Himalayas between elevations of 500 and 2 500 m which represent the most densely populated parts of the Himalayan Mountains. Cultivation of a variety of food and cash crops with livestock rearing constitute the traditional farming systems here. Livestock not only connects crop production with forests and rangelands and mediates the flow of biomass energy from forest and grassland to agriculture, it also constitutes the main source of food, livelihood, nutrition security and income in mountain communities. In the Himalayas, the mixed cropping pattern is one of the most characteristic of the traditional integrated farming systems which consists of five categories of crops: (1) cereals; (2) millets; (3) pulses and (4) vegetables and (5) oil seeds. This system not only helps in maintaining high crop genetic diversity under low carrying capacity of natural resources, but also ensures optimal production for food and nutrition security under severe geo-environmental constraints. The enormous diversity of cultivated and wild plants, provides a variety of edible products in diverse geo-environmental conditions and remains one of the most important features of traditional integrated farming systems. The Himalayan agricultural system consisting of a massive diversity of cultivated and wild plants provides food, nutrition and livelihood security to local communities and maintains the diversity and stability of traditional mountain farming systems. It can also help preserve landscape diversity and natural resources (Choudhary, 2013).

4.3.1.2 Livestock – pasture farming systems

This system is common in the higher Himalaya from 2 500 m to above 5 000 m and is mainly practiced in the Western Himalayan nations of India and in Pakistan. Sheep and goat flocks are reared on natural pasture in the Alpine zone mainly by indigenous communities with transhumance as common practice. In this system various animal products are exchanged and sold for food and income generation. In order to ensure food and nutrition security, the farmers also grow vegetables, root crops and a variety of lentils in the marginal lands particularly during summer month at higher elevations. This is one of the oldest form of production systems and has existed in the Himalayan Mountains for thousands of years (Choudhary, 2013).

4.3.1.3 Shifting cultivation

Shifting cultivation or slash and burn agriculture is a very common form of farming system practiced across the North Eastern Himalayan ranges in India and Myanmar. In this system, a piece of land is cultivated until the soil-nutrients and fertility decline, and then left abandoned for some years allowing the land to replenish; and cultivation is shifted to another patch of land (Ansari *et al.*, 2014). This is in fact the most comprehensive agro-ecological system ensuring food and nutrition security through the production of a range of crops, fruits, vegetables and livestock production system including piggery, poultry and fisheries and can help with conserving agro-biodiversity (Bahera *et al.*, 2004; Yadav *et al.*, 2013).

4.3.2 Upland intensive mixed farming system (East and Southeast Asia)

In East and Southeast Asia, the upland and hills of moderate elevation are characterized by complex terrain and varied climatic conditions ranging from humid, sub-humid, tropical and sub-tropical to temperate. These uplands provide a variety of agro-ecological landscapes for diverse farming practices with multiple crop and livestock combinations and shifting cultivation (Huddleston *et al.*, 2003). This is a common and diverse mountain farming system practiced with the terracing of hills of moderate altitude and slopes, and the use of organic matter to maintain soil quality in Indonesia, Lao PDR, Northern Thailand, Southern China, Philippines and Viet Nam (Huddleston *et al.*, 2003). This farming system is characterized by the cultivation of a wide range of mostly permanent crops including paddy, pulses, maize, sugarcane, oil-seeds, fruits, vegetables and livestock, depending on geographic area, agro-climatic conditions, slopes and availability of water resources. Livestock production is an important component of the system all across the region that contributes draught power, meat, cash income and can boost savings through the sale of livestock products such as milk, meat, manure etc. A large number of poor and marginalized households depend on off-farm activities for their livelihood under this farming system (Fullen *et al.*, 2011). Increasing population pressure is bringing more marginal lands under intensive cultivation without adequate soil and water management measures which is leading to the steady depletion of agricultural resources and increasing poverty and food insecurity (Panomtaranichagul and Fullen, 2002).

4.3.3 Highland extensive mixed farming systems (East and Southeast Asia)

This farming system is very common in the mountainous landscapes with humid and moist sub-humid agro-ecological conditions in East and Southeast Asia. The highland extensive mixed farming system is generally found above the upland intensive mixed farming system, but with poorer agricultural resources and lower population density (Roozitalab *et al.*, 2011). This farming is practiced in highlands and hills of Lao PDR, Central and North Viet Nam, Northern Thailand, Northern and Eastern Myanmar and Southwestern China where extensive forested areas are interspersed with farming areas, and with low to very low population density and extensive grazing areas (Huddleston *et al.*, 2003). Swidden (slash and burn agriculture) has been an important traditional farming system all across East and Southeast Asia for centuries. However, due to socio-economic transformation and change in the political order, this agricultural system is currently changing rapidly, mainly due to changes in the traditional natural resource use pattern, population growth, rural-outmigration, a decline in productivity and environmental conservation policies. In view of this, the highland extensive mixed farming system can be subdivided into permanent and shifting cultivation sub-types, both producing crops (including perennial crops such as fruit trees), livestock and forest products and providing livelihood for a large number of tribal communities. The main crops grown under highland extensive mixed farming system include upland paddy, pulses, maize, oil-seeds, fruits, forest products and livestock (Panomtaranichagul and Fullen, 2002).

4.3.4 Pastoral farming system (Highlands of Central Asia)

Pastoralism is practiced both in semi-arid and arid temperate agro-ecological zones with less than 120 growing days per annum in both valleys and mountains of large part of Central Asia, Mongolia, Eastern China, and the highland plateaus of South Asia and the Hindu Kush Mountains (Zoï Environment Network, 2012; Roozitalab *et al.*, 2011). The system is extensive in Western China and much of Central and Northern Mongolia, whereas it is highly intensive in the Central Asian highlands (Asian Development Bank, 2010). As many as 37 million rural mountain people in these sub-regions depend on such pastoral farming systems (Central Asian Mountain Partnership, 2008). Most of the pastures are located in high mountainous zones or adjacent dry zones. The farming system is dominated by

transhumance pastoralism and is characterized by mixed herds of camels, cattle, sheep and goats which graze extensively on native pastures and rangelands. Major crops in such regions include cotton, barley, wheat, pulses, peas, broad beans, potatoes, grapes and fodder crops which are grown at subsistence level (Huddleston *et al.*, 2003).

4.4 Constraints and emerging threats to integrated farming systems

A variety of traditional integrated farming systems constitute the main source of food and livelihood for a large proportion of population in the mountains of Asia (Tiwari and Joshi, 2018b). However, this conventional farming system is now collapsing due to various natural and socio-economic factors in most of the parts of the region.

4.4.1 Shifting cultivation systems and limited arable land

In the Eastern Himalayan Mountains, the shifting cultivation system is gradually becoming non-viable ecologically due to an increase in population and drastic reduction in its fallow period. These changes are not only depleting land, soil, water and forest resources; but also leading to the loss of agro-biodiversity and a decline in food production and income from agriculture (Ansari *et al.*, 2014). In Western Himalaya, a variety of changes have emerged in traditional agricultural resource use structure mainly in response to population growth, rapid urbanization, climate change, and increasing human-wildlife conflicts (Tiwari, 2008). As a result, land use patterns have changed and critical natural resources, such as, land, forest, water, and biodiversity have depleted steadily and significantly declining agricultural production and abandonment of agricultural land (Tiwari, 2000; Tiwari *et al.*, 2018). Moreover, the scarcity of arable land imposes severe constraints on sustained farming system in Himalaya as only, 8.3 percent of the total geographical area of Himalaya is available for cultivation (Maithani, 1996). As a result, in many parts of Himalaya, the availability of per capita land is below 0.2 ha which is too small to support sustainable food production and livelihood for all populations in the region. As a result, the majority of land holding size (95 percent) is of less than one hectare (Tiwari and Joshi, 2018a; Joshi, 2018; Aase *et al.*, 2013).

4.4.2 Migration and urbanization

The increasing trend of the abandonment of agricultural land has emerged as one of the serious threats to farming systems, particularly in Western Himalaya. The Himalayan State of Uttarakhand in India lost 10.32 percent of its agricultural land between 2001 and 2015 due to increasing trends in rural-outmigration and the resultant abandonment of farmland (Anmol, 2011; Tiwari and Joshi, 2018a; Joshi, 2018). The depletion of natural resources and resultant decline of agronomic production, climate change and frequent crop-failures caused by increasing incidences of extreme weather were identified as the main drivers of rural-outmigration and agricultural abandonment in Himalaya (Mamgain and Reddy, 2017). Moreover, in recent years, incidences of human and livestock killings and crop depredation increased due to a steadily growing wildlife population resulting in serious human-wildlife conflicts and abandonment of agricultural land. The increasing human-wildlife conflicts contributed to 75 percent of land abandonment and caused the loss of more than 1 500 human-lives, 1 100 heads of livestock and devastation of nearly 60 percent of crops in Western Himalaya over the last 10 years (Kansky and Knight, 2014). The Himalayas are not only the most densely populated mountain range but are also the most rapidly urbanizing mountains in the world. However, the process of urban growth is mostly unplanned and unsystematic, leading to extension of urban land use in peri-urban areas (Tiwari *et al.*, 2018). The Western Himalayan States of Himachal Pradesh and Uttarakhand in India, respectively, lost 4.71 percent and as much as 12.97 percent of their prime agricultural land due to urban encroachment over the last 30 years, causing huge decline in agricultural productivity (Tiwari and Joshi, 2011 and 2016; Tiwari *et al.*, 2018).

4.4.3 Climate change and diminishing water resources

The water resources of Himalaya are rapidly diminishing and depleting mainly due to land use changes and resultant hydrological disruptions and reduced ground water recharge (Valdiya *et al.*, 1991, Tiwari, 2000; Tiwari and Joshi, 2012a and 2012b; Rawat, 2009). These changes are reducing the availability of water for drinking, sanitation and crop production (Scott *et al.*, 2018; Trambe *et al.*, 2012). As a result, the region has lost nearly 15 percent of its irrigation potential over the last 30 years affecting farm productivity particularly in productive valleys (Tiwari and Joshi, 2012b). Moreover, recent studies have indicated that global climate changes have stressed the Himalayan agricultural system

through higher mean annual temperatures, altered precipitation patterns and more frequent and extreme weather events which are adversely affecting the food and livelihood security in Himalaya (Tse-ring *et al.*, 2010; ICIMOD, 2010, Scott *et al.*, 2018; Viviroli *et al.*, 2011; IPCC, 2014). The impact of climatic change is particularly severe in rain-fed agriculture in Himalaya where the balance between the availability and demand exists at a very low level with a high vulnerability. Further, it is expected that production of food is likely to decline mainly due to increasing water stress arising partly from rising temperatures and a reduction in number of rainy days, creating a very high risk of food insecurity (Tiwari and Joshi, 2012; Department of Science and Technology, 2010). The long-term impact of changing climatic conditions would certainly change the conditions for food production through influencing irrigation potential, cropping patterns, crop rotation, cropping strength, and cropping intensity; and as a result, increase the vulnerability of large population to climate change (World Bank, 2018; Cline, 2008).

4.4.4 Transformation of integrated farming systems

The introduction of High Yielding Varieties (HYV) of food and fruit crops particularly wheat, paddy and apple during the 1970s in the Indian Himalayan Region and the application of new farm technologies and modern farming inputs, specifically, chemical fertilizers, pesticides and insecticides and market influences had the effect of eroding values and knowledge of integrated farming system in the region. This transformation of mountain agriculture resulted in the loss of agrobiodiversity, depletion of natural resources and disintegration of farming system in Himalaya. These changes transformed the traditional mixed-crop farming system to monocrop cultivation leading to massive loss of agrobiodiversity.

Socio-economic and technical constraints; There are several socio-economic and technical constraints to sustained agricultural productivity in Himalaya. These constrictions mainly include (1) inadequate access to appropriate technologies to local communities, particularly in remote rural areas for optimal utilization of agricultural resources and increasing their productivity; (2) extreme lack of marketing and processing facilities for the agricultural, dairy and horticultural produces; (3) insufficient credit facilities for the agricultural sector; and (4) weakening community organizations and institutional framework for the optimal management and utilization of natural resources.

4.4.5 Poor management of agricultural resources

In the highlands of Central Asia, due to increasing livestock populations and poor management of agricultural resources, natural pastures and rangeland are depleting and degrading. As a result, the production of wool and other animal products is declining, which is resulting into widespread poverty all across the region, both in irrigated and pastoral areas. The increasing incidences of droughts and severe winters and resultant loss of livestock are triggering poverty, and food and livelihood insecurity, particularly in pastoral ecosystems. However, at higher elevations where cold winters lead to dormancy or very slow growth of crops and fodder species, cultivation of some crop is still possible, and animals can be grazed wherever the natural growth of fodder is available. The degradation of the natural resource base is disrupting the farming system leading to rampant poverty and food insecurity. The cultivation of rain-fed crops in the mountains of Central Asia has increased soil erosion on steep slopes, and overgrazing has exposed these mountain territories to a high risk of desertification. In addition, soil compaction, reduction of vegetative cover and increased erosion of mountain slopes is contributing to higher sediment formation and silt loading of the rivers with implications for the useful life and effectiveness of the reservoirs and irrigation canals and the generation of hydro-power (Zoï Environment Network, 2012).

The increasing population in hilly and mountainous areas of East and Southeast Asia is depleting the natural resource base and resulting into lowered yields, loss of biodiversity, scarcity of water in the dry season, poverty and increasing food and nutrition security. This is pushing crop cultivation to more fragile and steep slopes, and decreasing the length of the fallow period in shifting cultivation cycles. Collectively, these factors have an adverse effect on agricultural resources and their carrying capacity and on environmental and socio-economic sustainability across the region. Furthermore, government agencies and large timber companies have been responsible for widespread and unsustainable logging of natural forests throughout the upland areas leading to degradation of upland water and soil resources and declining farm productivity. The low level of development of rural infrastructure, marketing and communication facilities is also affecting the sustainability of upland agriculture and food and nutrition security of communities. Moreover, the changing climatic conditions have already stressed traditional food and agricultural systems through higher mean annual temperatures, altered precipitation

patterns, hydrological disruptions and more frequent and extreme weather events in the all across the mountain regions of Asia (IPCC, 2014; ICIMOD, 2010).

4.5 Restoration and development of integrated farming systems in the mountains of Asia

As discussed earlier, a large proportion of rural population in mountain regions of Asia depends on traditional agriculture for its livelihood and supply of food even though the availability of agricultural land is considerably limited and productivity is low (Anmol, 2011). Nevertheless, agriculture will remain one of the important economic activities in the region not only being the main source of food and livelihoods, but also comprise one of the core components of overall development and climate change adaptation strategies all across the mountain regions of the continent (Jodha, 2005; Tiwari and Joshi, 2018a). This is because agriculture is not merely an important economic activity and constitutes a fundamental source of livelihood and food for local rural communities but farming also constitutes an invaluable source of traditional ecological knowledge, sustainable resource management practices and grassroots institutional mechanism (Jodha, 2005). In addition, mountain regions offer highly productive and agriculturally prosperous valleys, mid-slopes, pastures and rangelands with wide agroclimatic diversity which have great potential to contribute towards the food as well as livelihood security in mountain communities (Zoï Environment Network, 2012). Also, potentially these varying agroclimatic zones, from valleys to higher elevations can be utilized for the diversification as well as integration of agriculture, horticulture, floriculture, dairying, and forestry.

For this to be a success, all sustainable development strategies aiming to attain food and livelihood security, distributive growth and economic justice, environmental sustainability and community empowerment in mountain areas need to be linked with local agricultural and food systems (Asian Development Bank, 2010). Such integration of different sectors of the mountain economy with local agricultural production systems will create local viable markets and so make local agriculture economically viable (Campbell, 2008).

In the mountain regions of Asia, the geo-environmental constraints result in inaccessibility. In addition, It is difficult to make use of modern agricultural inputs, such as fertilizers, irrigation etc. in high mountains characterized by high altitude, steep and fragile slopes

Box 4.1 Integrated farming systems for enhancing productivity and profitability under hill and mountain agro-ecosystems: a case study on the under-forestry economy (UFE) in China

Development status of the UFE in China

The UFE in China has a long development history, but in its original state, it was a phenomenon of self-organization by farmers looking to improve their livelihoods. In 2012, after the collective forest tenure reform, the promulgation of the "Opinions on Accelerating Development of UFE" directly promoted the rapid development of UFE, which includes under-forest cultivation, under-forest breeding, forest product collection and processing, and forest tourism as ways of improving livelihood opportunities. By the end of 2017, there were more than 400 million mu (267 000 km²) of forest land being used to develop the UFE. In addition, more than 60 million farmers, 20 000 professional cooperatives and more than 2 000 leading enterprises participated in the development of the UFE. This meant that the UFE in China was constantly improving and the output value of UFE in China exceeded CNY 750 billion in 2017¹.

The impacts of the UFE in China

The development of UFE contributes to the improvement of farmers' income and rural livelihoods by increasing the productivity of various new income sources. The related research and assessment results show that the development of the UFE can enhance the income growth of farmers,² especially low- and middle-income farmers,³ which means that this integrating practice plays a significant role not only in addressing hunger and malnutrition in poor hill and mountain areas, but also in promoting rural development. Moreover, the development of the UFE plays a positive role in protecting the ecological environment on various levels, thereby preserving forest resources. The development of UFE also has an important impact on ensuring food security and the provision of safe food for society at large.

The keys to success: why does it work?

The development of UFE is depends of the work of many people and organizations, but the government's guidance, promotion and support are undoubtedly the most important factors. Relevant government departments and local village committees have carried out publicity and support work, provided various skills training as well as incentive policies (Up to October 2016, 25 provinces in China issued provincial-level development plans relating to UFE; a further 14 provinces had given special financial support to UFE).

Another reason UFE development in China has been a success, is that highly-talented people play significant roles. By utilizing their economic expertise, market consciousness, cooperation awareness and brand perception, they lead and organize local forest farmers to develop the UFE in a profitable direction.

It is also particularly important to choose a suitable development model and a development strategy that takes local conditions into account. Superior resources can be used to develop and unique UFE products but this needs to be carried out in a way that protects resources.

It is the needs of farming communities that have ensured the rapid development of the UFE. Forest farmers now have management rights in forests and after the forest tenure reform, ownership of trees too. But there are still restrictions on cutting trees in protected areas. So the UFE is a way of protecting forest resources while also ensuring that local people have another source of income.

¹ The 5th China UFE Development Symposium (2018) Outline of the "Under-Forestry Economy" Development Plan for Collective Woodland in China (2014–2020)

² From the survey of UFE in GUANG XI and research results of the related dissertation (2017).

³ From the survey of UFE in GUANG XI and research results of the related dissertation (2017).

and a cold climate. This not only decreases farm productivity but also restricts communities' access to market and means that it is hard to get favourable terms when it comes to trading. (Asian Development Bank, 2010). However, at the same time, mountains have huge potential considering the diversity of mountain farming systems, the special niche of mountain areas, the local institutional framework and adaptive capacity of local communities to develop coping mechanisms to environmental changes and risks. There is a huge potential for making mountain farming an ecologically

conductive, economically viable and socially accepted means of food, livelihood and nutrition security all across the mountain regions of the continent.

In order to harness this potential, it will be necessary to find ways to enhance the utilization intensity and physical and economic input absorption capacity of land, evolve strategies for harnessing niche and the potential of diversities ensuring high productivity without degrading the ecosystems and depleting the natural resource base. There will also be a need to

improve capacity to cope with the emerging risks of climate change and natural disasters (United Nations Environment Programme, 2007 and 2008). This would require an integrated watershed management approach in which the integrated farming systems should be mainstreamed into an overall process of development planning; and comprehensive agroclimatic zonation based on altitude, temperature, precipitation, soils, and slopes.

Furthermore, in order to ensure the ecological sustainability and economic viability of the integrated farming systems in mountain areas it is important to:

- A** Develop an agricultural resources information system at watershed level.
- B** Diversify agriculture production based on special niches.
- C** Develop value chain system and marketing facilities based on locational planning of agricultural facilities and services.
- D** Integrate mountain farming systems with other sectors of economy, particularly tourism.
- E** Attract more investment in mountain agriculture.
- F** Manage the risks and take advantage of the opportunities of economic globalization.
- G** Evolve strategies for productive use of fragile slopes and marginal lands.

The development of suitable crop varieties for cold to very cold highland regions and effective technologies for conservation and diversification of traditional agriculture in the cold, arid and semi-arid highlands will be essential to ensure the sustainability of integrated farming systems in the mountain regions of Central Asia (Central Asian Mountain Partnership, 2008 and Regional Environmental Centre for Central Asia, 2014). This will also require the diversification and integration of entire agriculture production systems such as inclusion of horticulture, vegetables medicinal and herbal crops (FAO, 2011). Moreover, evolving appropriate and effective climate change adaptation strategies in natural resources and the farming sectors and developing disaster risk reduction frameworks at watershed levels will be inevitable all across the mountain regions of Asia to ensure economically viable integrated agricultural production systems.

4.6 Conclusions

The mountain regions of Asia provide some of the best examples of integrated mountain farming systems which have evolved over thousands of years despite the fragility, inaccessibility and marginality which leads to low carrying capacity of natural resources in mountain areas. However, over recent years, the values of traditional mountain farming systems have eroded mainly due to population growth, rapid urbanization, the depletion of the natural resource base, economic globalization and market influences and climate change.

However, by capitalizing upon both the sociocultural and biophysical strength of the mountain landscape, integrated farming systems have the potential to contribute significantly towards attaining food and nutrition security as well as securing viable livelihood opportunities for mountain communities. The potential of agroclimatic diversity in mountain areas ranging from productive valleys to higher elevations can be optimally utilized for the diversification and integration of agronomic or field crops, livestock farming, horticulture, floriculture, dairying, fishing, beekeeping and forestry at watershed levels. The development of value-addition products would be necessary for ensuring the sustainability of the entire integrated mountain production system in mountain areas. In order to attain this, the mountain farming systems should be considered as one of the integral components of sustainable mountain development planning.

Mountain agriculture therefore needs to be integrated with ongoing poverty eradication programmes, food and livelihood improvement strategies, and rural employment schemes as well as with ecological restoration and climate change adaptation mechanisms at national, regional and international levels. Furthermore, integration of different sectors of the mountain economy with local agricultural production systems, increased credit in rural areas, and increased investment in mountain agricultural enterprises will help to make all types of mountain farming systems economically viable and ecologically sustainable.

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5 Sustainable mountain agriculture through integrated and science-based watershed management: A case study

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5.1 Introduction

Agriculture in mountain areas is essential for the world's food security. Mountains account for one quarter of the world's land surface and are home to 12 percent of its population. More vitally, 50 percent of the world's population depend on the water and ecosystem services that mountains provide. Mountain areas are characterized by topography of variable altitudes and variable climatic conditions and so are major reservoirs of global biodiversity.

Mountain ecosystems are largely fragile and rainfed, and are a high-risk environment throughout the year. Mountain systems are extremely vulnerable to climate variability and the implications of climate change. People who live in mountain regions are often amongst the poorest and most food insecure people in the world due to the harsh conditions of the terrain, poor infrastructure development, lack of services and general isolation. However, mountain regions are increasingly popular tourist destinations worldwide attracting over 50 million visitors annually which can provide the opportunity to popularise FSF and also create additional income for the locals.

Achieving Zero Hunger for a world population that is expected to pass the 9 billion mark by 2050 is a major challenge. Moreover, ensuring that nutrition is balanced is also important, especially when both malnutrition and obesity are growing concerns globally as a result of poor or unhealthy diets.

As a natural resource, our water supply is finite and circulates through the water cycle in a process of evaporation, transpiration and precipitation driven

mainly by various climatic and land management factors (Falkenmark, 1997). Of the 1 385.5 million km³ of water available on earth, 97.3 percent is salt water in oceans with only 2.7 percent fresh water, which is the lifeline of the biosphere, where forest, woodlands, wetlands, grasslands and croplands are the major outputs (Shiklomanov, 1993; Postel *et al.*, 1996; Rockström *et al.*, 1999). Of the annual precipitation (1 110 305 km³), only about 35 percent (38 230 km³) returns to the ocean surface as run off, while the remaining 65 percent is converted into water vapour. The availability of water resources per capita will decline as the world population keeps growing. For example, per capita water availability in India decreased from 5 177 m³ in 1951 to 1 820 m³ in 2001 due to the increase in population from 361 million in 1951 to 1.02 billion in 2001. This population increase is expected to continue, with a rise to 1.39 billion by 2025 and 1.64 billion by 2050, with a corresponding decrease in per capita water availability of 1 341 m³ by 2025 and 1 140 m³ by 2050, respectively. Although mountains provide fresh water resources to 50 percent of the world's population, people living in mountain regions face water scarcity during the dry months of the year. This contributes to both food insecurity and poverty. But poverty and food insecurity also exist in mountain areas where there is high precipitation. This is because of poor agricultural productivity, a lack of infrastructure and little development due to the twin challenges of topography and isolation. This is in line with the well-established nexus between hunger, water scarcity and poverty worldwide (Falkenmark, 1986). Adopting a science-based holistic integrated watershed approach is vital for addressing the major challenges of water scarcity, poverty and hunger in mountain regions (Wani *et al.*, 2018).

Table 5.1 Details of case watershed sites in China and Thailand

Site	Region	Geographic position	Number of families	Rainfall (mm)	Soil type	Major crops/cropping systems
Xiaoxincun	Yunnan, China	25° 36' 14" N/ 103° 13' 12" E	86	640	Ultisols, Inceptisols	Rice, vegetables (broad bean, chilli, corn, groundnut, sweet potato, watermelon)
Lucheba	Guizhou, China	26° 35' N/ 106° 43' E	365	1 284	Ultisols, Inceptisols	Cabbage, corn, kidney bean, rape, rice, soybean, sunflower, watermelon and vegetables (chillies, eggplant, pumpkin, tomato, etc.)
Tad Fa	Khon Kaen, Thailand	15° 30' N/ 101° 30' – 140° 30' E	358	1 300	Ustults	Bamboo, maize, vegetables, plantation, tamarind
Wang Chai	Khon Kaen, Thailand	16° 30' N/ 102° 47' E	358	1 171	Ustults	Paddy, groundnut, soybean, sugarcane, cassava, cowpea, fruits vegetables

5.2 Characterization of case studies of watershed areas in China and Thailand

The details of sites of farmer participatory watershed management initiatives managed and implemented by an ICRISAT-led consortium in China and Thailand are shown in Table 5.1.

The major constraints for crop and food production are lack of water due to low and erratic rainfall, and severe land degradation from soil erosion causing large gullies and water run-off due to steep slopes that results in frequent droughts. Farmers living in the watersheds, therefore, may be resource poor and not have the knowledge to take on new and emerging challenges.

5.3 Participatory, integrated and consortium approaches for watershed management

An ICRISAT-led consortium undertook comprehensive assessments of watershed programmes in India and the meta-analysis of 636 watershed case studies from different agro-eco regions. The findings revealed that watershed programmes were silently revolutionizing rainfed areas and were economically remunerative for farmers. Some 99 percent of these programmes showed a benefit-cost ratio of 2:1 with an internal rate of return of 27.2 percent (Joshi *et al.*, 2008). These programmes benefited farmers by increasing irrigated areas by 51.5 percent, improving cropping intensity by 35 percent, and reducing soil loss to 1.1 tonnes/ha⁻¹ and runoff by 45 percent. There was also an improvement in the availability of groundwater. However, about

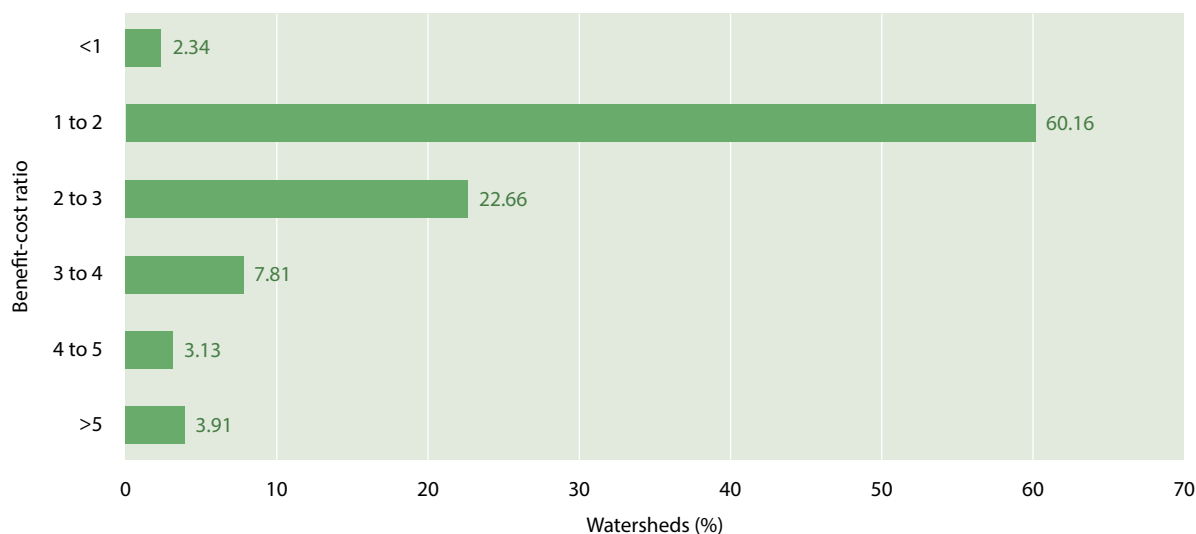
62 percent of the case studies showed a below average performance (Figure 5.1). Better performances of watersheds were realized in the rainfall regime of 700–1 000 mm. This indicates a need to develop technologies suited to areas with a rainfall regime of less than 700 mm and more than 1 000 mm.

The results of the meta-analysis regression indicated that the benefits of watershed programmes vary depending upon the location, rainfall quantity and intensity, rainfall patterns, and the implementing agency. It is also important to emphasize that the status of the target population and people's participation play a deterministic role in the performance and efficiency of such watershed programmes (Joshi *et al.*, 2008).

5.3.1 Integrated watershed management to enhance productivity and resilience

Watersheds are not only hydrological units but also connect upstream and downstream areas while providing life support to rural populations by making people, crops and animals an integral part of the watershed system. The activities of people, such as growing crops and raising livestock can affect the productive status of watersheds. Water scarcity (drought) due to land degradation can be addressed through a system of integrated watershed management.

A new generation of watershed development programmes has been implemented with the larger aim of addressing issues of food security, equity, poverty, severe land degradation and water scarcity in dryland areas. This new approach is people-centric and integrated for achieving Zero Hunger and improved

Figure 5.1 Meta-analysis of watershed programmes in India based on economic parameters

Source: Joshi *et al.*, 2008

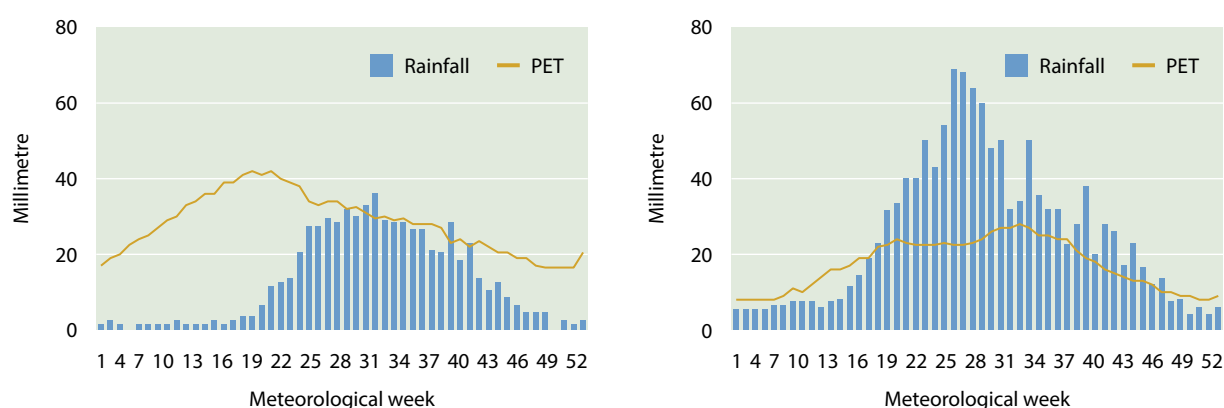
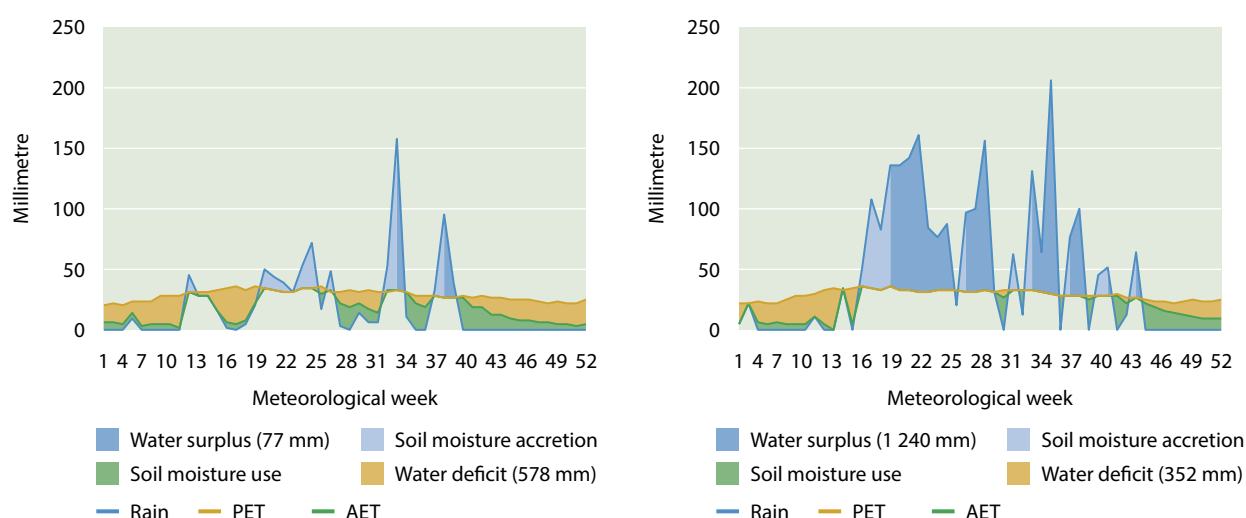
livelihoods through sustainable management of natural resources. These recent watershed initiatives have been looking beyond soil and water conservation into a range of activities from productivity and profitability enhancement to interventions in agriculture, including both agronomic and horticultural crops, and animal husbandry. They also involve community organization and gender equity to build climate resilience (Wani *et al.*, 2002, 2003 and 2007a). This more holistic approach requires optimal contribution from people of different disciplinary backgrounds to create a demand for multi-stakeholder watershed development programmes.

In Asia, ICRISAT in partnership with national agricultural research systems, non-governmental organizations (NGOs) and the private sector have developed and evaluated an innovative farmers participatory integrated watershed consortium model aimed at increasing agricultural productivity and eventually improving rural livelihoods (Wani *et al.*, 2003, Wani *et al.*, 2014). The conventional watershed approach was compartmental, structure-driven and lacked an effective strategy for efficient use of resources. Though watersheds served as the entry point, a paradigm shift was needed from these traditional structure-driven watershed programmes to a holistic systems approach to improve livelihoods, help alleviate poverty and to achieve food security through increased agricultural productivity using environment-friendly resource management practices (Wani *et al.*, 2003, 2008a, 2014). Watershed management should also lead to exploring multiple livelihood interventions (Wani *et al.*, 2006, 2007a, 2008a), which allows the new community watershed management

model to fit into the livelihood framework as a tool to assist in the sustainable development of rural livelihoods (Wani *et al.*, 2008).

The ICRISAT consortium model for community watershed management adopted the principles of convergence, cooperation, collective action, and capacity building (termed the 4Cs). Technical backstopping came from a consortium of institutions to address the issues of equity, efficiency, economics and the environment (termed the 4Es) (Wani *et al.*, 2008b). Later, Innovations, Integration, Inclusivity and Intensification (termed the 4Is) were added thereby leading to the development of the 4 ICEs model (Wani *et al.*, 2018b). The new integrated community watershed model provides technological options for management of surface water harvesting and waterway systems, *in-situ* conservation of rainwater for recharging groundwater, and supplemental irrigation. It also provides for the appropriate management of nutrients and soils, crop production technology and appropriate farming systems with income-generating micro-enterprises for improving livelihoods while protecting the environment (Wani *et al.*, 2002, 2007a, 2007b; Sreedevi *et al.*, 2004).

To achieve equity for small farmers, a focus on demand-driven low-cost technologies with built-in tangible economic benefits comprises an integral component of participatory watershed management. This helps to ensure increased and effective individual participation. In a survey undertaken in watersheds in China and Thailand, 70 percent of the local people were involved from the initial stage. The same high

Figure 5.2a Water balance in Tad Fa watershed in Thailand: data for the wet year of 2000 (left); data for the dry year of 2001 (right).**Figure 5.2b** Water balance in the Xiaoxincun (left); and Lucheiba (right) watersheds in China

Source: Wani *et al.*, 2012

percentage of the population attended all meetings. Twenty-seven percent of the population were involved in decision-making, and 83 percent were involved in carrying out allocated tasks. Empowerment, involvement and ownership of the local communities in decision-making and the execution of tasks were the main reasons behind the success of the watershed management interventions. The ownership and important benefits to the communities helped to institutionalize watershed management to ensure that users would be willing pay for the interventions. This introduces the sustainability component in watershed management, allowing it to continue when the external aid, used to initiate watershed programmes, is phased out.

A consortium of multidisciplinary experts from different institutions supported farmers in taking forward the watershed management programmes at study sites in China and Thailand. In the case of the watersheds in China (at Xiaoxincun and Lucheiba), the consortium was

made up of experts from the Integrated Rural Development Centre (IRDC) of Guizhou Academy of Agricultural Sciences (GAAS), Guizhou; the Tropical and Subtropical Cash Crops Research Institute of Yunnan Academy of Agricultural Sciences (YAAS), Kunming; and ICRISAT, Patancheru. For watersheds in Thailand (at Tad Fa and Wang Chai), the consortium was comprised of experts from the Royal Thai Department of Agriculture, Royal Thai Department of Land Development, Khon Kaen University and ICRISAT.

5.3.2 Water budgeting to plan a water management strategy

Before a water management strategy can be put in place, a water budgeting or a water balance of the identified watershed area has to be undertaken to assess the occurrence of dry spells, as well as excess water available for harvesting based on the rainfall, soil moisture/water status and potential evapo-transpiration (PET) of the area.

Table 5.2 The impact of improved watershed management in reducing runoff water

Country	Study site	Rainfall (mm)	Runoff (mm)	Runoff as percentage of rainfall
China	Xiaoxincun	344	24.3	7.1
India	Kothapally	743	44.0	7.8
Thailand	Tad Fa	1 284	169.0	13.2
	Wang Chai	940	210.0	22.3

Water balance/budgeting in the potential watershed areas can differ drastically during wetter and drier years as compared to years where rainfall patterns are more normal. The process can be further affected by climate change, even when the total rainfall quantity has not been affected. This is because the change in rainfall distribution or the number of rainy days and the rainfall intensity affects the water balance of the watershed. The watershed interventions under discussion were planned based on the previous 30 years of average rainfall quantity and intensity. There is an urgent need to consider the growing impacts of climate change on rainfall quantity and intensity, rainfall distribution, and the occurrence of dry spells during the crop-growing season for planning water management strategies in the watershed. It is no longer possible to take a business-as-usual approach due to the serious implications of climate change, more specifically the increase in the number of days when rainfall intensity is high and the decrease in the total number of rainy days causing more dry spells during the crop-growing season (Rao *et al.*, 2016).

In the Tad Fa watershed in Thailand, more rainfall than the potential PET was observed from the first week of April until the last week of October during the wet year of 2000 (Figure 5.2a left). Although, there were weeks when rainfall was less than the PET, as the soil was fully saturated by the last week of April, a water surplus

(1 240 mm) was available for managing efficiently. However, a 352 mm annual water deficit was experienced during the dry period of the year. During 2001, a dry year, rainfall surpassed PET from the last week of April and this continued up to the middle of September (Figure 5.2a, right), resulting in a small (77 mm) water surplus over two weeks and a considerable annual water deficit of 578 mm.

In China, the Xiaoxincun watershed showed a high annual PET of about 1 464 mm compared to rainfall of 640 mm, with a large water deficit (Figure 5.2b left). The Xiaoxincun watershed in Yunnan province experienced very little water surplus for a short duration in the rainy season only, suggesting that *in-situ* rainwater conservation measures would be economically more rewarding and investments in *ex situ* rainwater harvesting could be moderate in benefits. However, another watershed in a nearby province Guizhou showed a lower annual PET of 891 mm with 1 284 mm annual rainfall. This resulted in a large (384 mm) water surplus, particularly during June and July (Figure 5.2b, right).

Such studies on distribution of various water balance components reveal uneven distribution of rainfall during the year and suggest the need to adopt measures for efficiently harnessing and conserving surplus water during rainy periods to counter water deficits,

Figure 5.3 Various interventions implemented in the watershed

Table 5.3 Changes in area and yield of major crops before and after watershed management in the Lucheba watershed in China

Crops and cropping system (intercrop or sole crop)	Before		After	
	Area (ha)	Yield (kg/ha)	Area (ha)	Yield (kg/ha)
Corn (intercrop)	3.230	29 563	0	0
Corn (sole crop)	1.840	24 918	0	0
Rice (sole crop)	5.113	29 782	0	0
Cabbage	0	0	4.00	363 549
Tomato (sole crop)	0	0	3.40	640 880
Pepper (sole crop)	0	0	2.04	281 690
Cucumber	0	0	0.66	443 147
Chilli (sole crop)	0	0	1.40	299 786

particularly during dry periods of the year or in a dry year itself. Improved watershed management can be achieved by constructing water harvesting structures, contour cultivation across slopes, the planting of *Gliricidia* on bunds (embankments), ensuring less exposed soil erosion through increased cropping intensity, increased use of organic manures, and better crop growth due to adoption of new varieties aimed at offering more balanced nutrition. All these practices would restrict the free flow of water, leading to more infiltration and reduce runoff in comparison to the rainfall received (Table 5.2), as generally more than 30 percent of rainfall is lost as runoff. The reduced runoff infiltrated into the soil would augment green water sources in rainfed agriculture. Green water sources are vital for food production with almost three times more green water being used than blue ($5\,000$ versus $1\,800\text{ km}^3\text{ y}^{-1}$), (Karlberg *et al.*, 2009). Soil erosion, which is a major environmental problem particularly in Yunnan province of southwest China and other parts of the semi-arid tropics (SAT), including the benchmark site Tad Fa in northeast Thailand, will decrease due to

improved watershed management measures that would restrict displacement of soil particles and loss thanks to the reduced water runoff (Figure 5.3).

5.3.3 Impacts of integrated watershed management in the Lucheba watershed in China

In the Lucheba watershed in China, land-use patterns at the household level changed favourably after improved irrigation resulted in a 94 percent increase in irrigated areas and a 34 percent reduction in rain-fed areas (Wani *et al.*, 2013). The area under high-value horticultural crops, such as vegetables, increased significantly for the average household due to more effective water conservation measures and other improved management practices.

Crop Production System: The impact of watershed development on crop production system and related components was assessed in the Lucheba watershed in China through participatory rapid rural appraisals (PRRA).

Figure 5.4 Community and farming nursery of sweet potatoes

Table 5.4 Changes in crop production system and field inputs and outputs in 2003 and 2012 in the Luchebe watershed in China

S. Number	Indications	2003	2012
1	Cropping system		
	a. Summer	Rice, maize	Vegetables – Chinese cabbage chilli, tomato
	b. Winter	Rapeseed	Vegetables – Chinese cabbage
2	Cropping intensity (%)	100 – 150	300
3	Irrigation area	Largely rain-fed	Total irrigated
4	Use of improved seeds	Partial	Total cropped area under high-yielding varieties (HYVs)/hybrid
5	Fertilizer use (tonne)	Yes	Yes
	Nitrogen (N)	21.3	78.0
	Phosphorus (P)	5.8	4.2
	Potassium (K)	8.8	10.0
6	Use of agriculture. Plastic films	Nil	15 000 kg
7	Mulch film	Nil	14 800 kg
8	Area under mulch film	Nil	7 500 mu
10	Area ploughed by tractor	Nil	3 500 mu
14	Net income	CNY 1 057 per ha	CNY 3 680 per mu
15	Fuel availability	Forest based	Liquid petroleum gas and electric
16		Wood, bio-gas	Cooking modes
17	Drinking water	Acute shortage	Adequate and reliable water availability
18	Migration from village	Important part of livelihood	Nil, due to crop diversification being higher Opportunity cost for labours

Source: RRA-July 14, 2013

Box 5.1 The Luchebe watershed at glance: 2012

The total area of the Luchebe watershed is 7.2 square km and it has a total population of 1 370, of whom 860 are labourers. There are 11 villages at 1 340 m above sea level and six Farmers Groups. Arable land accounts for 3 350 mu (1 ha = 15 mu) of which 3 300 mu is irrigated and 50 mu is now dry land. Forest coverage is 43.8 percent. Thirty-five farmers have become trainers and instruct other farmers, and 85 farmers having earned the title of Farmer Technician. Vegetables are grown on 10 000 mu, three times the amount grown on total irrigated land in 2002. Annually 30 600 tonnes of produce is sold, with a product gross value of CNY 36.8 million and a net per capita income of CNY 6 800 in 2011 and CNY 8 100 in 2012, which is an increase of 19 percent in per capita income within one year. In 2012 chillies were grown on 1 500 mu, tomatoes on 500 mu, Chinese cabbage on 1 000 mu and beans, eggplants (*brinjal*), etc. on 300 mu.

The benchmark crops before starting the project were corn, kidney bean rapeseed, rice, soybean and sunflower. But after watershed implementation cabbage, watermelon and other vegetables such as chilli, eggplant, pumpkin, and tomato are being cultivated with improved agronomical practices and using hybrid seeds. A major shift in crop area and yield levels at the household level can be shown in Table 5.3. The area

under maize, peas and rice cultivation decreased by 18 and 38 percent, respectively, in favour of the increased area under high-value horticultural crops such as vegetables which increased by two to six times (Wani *et al.*, 2013). Similarly, after watershed management, yield levels of field crops increased in the range of 6 to 19 percent for maize and rice, while for different vegetables the increase in productivity was in

Box 5.2 The improving prosperity and livelihood of Mr Yixianyou in the Lucheba in China through integrated watershed development

Back in 2002, Mr Yi and Mrs Liu Rui and their son Mr Liu Yong made a living by cultivating 1.3 ha of agricultural land in the Lucheba village of Kieanong Township in Pingba County of Guizhou Province in southern China. Mr Li and Mrs Liu Rui used to grow maize and millet, and struggled to produce sufficient food for their family's food security. The son, Yong migrated to work in the city as a construction worker when he had completed high school. Their family income in 2002 was around CNY 3 500 per annum (a per capita income of CNY 1 200 per year). They were living in an old house in the village and were looking for way to move out of poverty.

In 2013 researchers visited Mr Yi and his family, and were greeted with the sight of their grandson playing with a remote control car in the courtyard of the family's gated, two-storey house. Mr Yi was in the house, sitting on a comfortable sofa and taking part in a meeting involving ten farmers of his group who were discussing an impact assessment of ICRISAT-Asian Development Bank (ADB) project on integrated watershed. The house was well designed and constructed, with a fully equipped kitchen that included an induction plate on a cooking platform and an excellent set of utensils and crockery. In the adjoining room was a 36-inch LED TV with a dish antenna and DVD player, as well as a music system, a refrigerator and water purifier supplying cold and hot water. In the main hall, the researchers spoke to Mrs Liu Rui with Dr Hao Wieping from the Chinese Academy of Agricultural Sciences (CAAS) acting as a translator.

Mrs Liu said, "Our annual income is about 50 000 to 60 000 (CNY) (USD 8 333 to 10 000) and we don't want to go to city at all to make a living. We enjoy our life here. In fact, our son who had worked in the city earlier has come back and joined the family to farm. "This house is for their son with Mr Yi and Mrs Liu Rui having a separate house in the village but the whole family stays together. Eight years ago they constructed the first floor of this house on land that is their ancestral property. Five years later, they decided to add a second floor and spent about CNY 200 000 (USD 33 330) on construction. Mrs Liu said, "we used to grow corn and millet but since 2003 we slowly moved into growing vegetables and now we only grow vegetables. It pays well and four years ago we purchased a fridge for the house, and two years ago we bought a car. First we purchased a motorcycle and small tractor (power tiller) for cultivating our land, then we acquired a small truck for vegetable produce transportation." She very humbly pointed to all their assets in the shade of the courtyard.

Mrs Liu's main concern was that there is little extra labour in the village and all the fieldwork is done by family members only. So their son has also joined them along with their daughter-in-law. They had spent about CNY 50 000 (USD 8 330) on gifts to the bride on the occasion of their son's marriage. Researchers asked Mrs Liu about financial loans, and she was adamant that the family hadn't taken any out. In response to the inquiry as to whether they can get additional land for cultivation in the village, she said, "No land is available here now for leasing or purchasing." When asked about the family bank balance, Mrs Liu gave an estimate of CNY 20 000 to 30 000 (USD 3 330 to 5 000). Her first priority for investment is house construction for the whole family then saving funds for risk reserves for years of bad agriculture. She said, "We are a middle class family in the village and there are at least 200 families who have similar living standards."

By now Mr Yi had finished his meeting with the farmer's group members and joined the discussion. To validate what they had heard from his wife about the income and his investment priorities, researchers made enquiries. Mr Yi said that his first priority was his grandson's education and investment in the business such as transportation, as other needs for housing and household appliances had now been met. The total income from agriculture for their family is about CNY 70 000 to 80 000 (USD 11 660 to 13 330) per annum and net income or profit is CNY 30 000 to 40 000 (USD 5 000 to 6 660) per annum. Mr Yi said the family had a current bank balance of CNY 40 000 (USD 6 660) higher than his wife's estimate of CNY 20 000 to 30 000.

the range of 32 to 673 percent. The similar yield levels of farmers are a clear indication of a significant contribution of well-designed technical and extension support services to farmers in the Lucheba watershed. The rapid rural appraisal (RRA) and focus group discussions (FGDs) also backed this evidence.

Farmers do apply considerable quantities of chemical fertilizers and pesticides to their crops. To conserve soil moisture, a large quantity of plastic mulch film is used to cover most of the cropped area. This is a recent innovation in production systems (Figure 5.4), in addition

to the use of tractors for ploughing. All these practices in the post-watershed period have increased land productivity, total production and have boosted the sale of farm produce. This has led to increased village income and has reduced migration significantly. Another impact of conserving soil moisture by the use of plastic mulch has been an increase in the availability of irrigation and drinking water. A sizable reduction in the livestock population has been observed by the villagers, except for backyard poultry raised for home consumption (Table 5.4).



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Table 5.5 Impact of watershed management interventions on forage production development in the Lucheba watershed in China

Year	Area under forage (ha)	Yield (t ha ⁻¹)	RWUE (CNY mm ⁻¹ ha ⁻¹)	Net monetary return (CNY ha ⁻¹)	Benefit-cost ratio
2003	8.4	36.9	28.8	13 220	1.4
2005	15.7	41.9	32.6	22 473	1.8

5.3.4 Forage production and animal-based livelihoods

Increased water availability as a result of effective watershed management has enabled farmers to increase not only cropping intensity, but also diversification of their land-use production systems involving horticultural or forage crop on sloping lands. In the study site at the Lucheba watershed, the area under forage production increased by 87 percent, from 8.4 ha in 2003 to 15.7 ha in 2005 (Table 5.5), which resulted in two major benefits: arresting soil erosion on sloping lands and increasing forage supplies for a livestock-based production system. The maximum area under forage crops was under rye (85 percent), followed by alfalfa (13 percent). Livestock including ruminants are important components of mixed crops-livestock farming systems that can provide an alternative source of income to improve livelihoods. Mixed farming systems also improve resilience to commodity price volatility and impacts of climate change. The holistic watershed management interventions substantially increased the livestock population and agriculture productivity at the Lucheba watershed. The substantial increase in animal population

also proved instrumental in promoting biogas plants for to meet the daily energy needs of households in watershed areas. Construction of biogas plants in the Lucheba watershed area has increased, and now more they meet the energy needs of more than 230 homes in the village. By switching over to biogas plants to meet domestic energy requirements, one household saved about CNY 690 (USD 87) per annum because there was no longer a need to purchase coal, and saved 3–4 hours a day of hard work for women per day as they no longer needed to collect fuel wood from the forest. So the biogas initiative is also helping to conserve local forests and woodlands.

5.3.5 Input utilization, output and income patterns in crop production

The introduction and cultivation of high-value vegetable crops in the Lucheba watershed in China, has greatly increased the need for labour, machinery and animal power in comparison to more traditionally grown field crops like rice and corn. Similarly, the use of fertilizers and pesticides for plant protection is much higher for vegetable crops compared to field crops (Table 5.6), and

Table 5.6 Various inputs used in the production of different crops during 2012 in the Lucheba watershed in China

Inputs	Crop type					
	Corn	Rice	Cabbage	Pepper	Tomato	Chillies
Working Power						
Human labour (person days/ha)	121.0	235.0	157.0	186.0	356.0	196.0
Machinery (hours/ha)	6.6	13.2	15.5	16.3	16.3	16.9
Animal power (hours/ha)	36.4	51.6	15.8	23.5	14.3	22.5
Fertilizer (kg/ha)						
Nitrogen (N)	838	1 073	1 044	1 479	1 268	1 050
Phosphorus (P)	987	1 561	1 512	1 897	2 325	1 425
Potassium (K)	280	289	372	525	864	211
Other (specify)						
Pesticides for plant protection (litre/ha)	3.9	3.6	5.1	7.1	14.2	9.7
Seed (kg/ha)	30.0	20.0	0.6	0.5	0.2	0.6

Table 5.7 Cost of inputs, yield levels and net returns in different crops produced during 2012 in the Lucheba watershed in China

Inputs	Crop type					
	Corn	Rice	Cabbage	Pepper	Tomato	Chilli
A Cost of inputs (CNY/ha)						
1 Labour						
Human	700	583	1 610	1 856	1 674	1 342
Machine	277	245	500	504	507	501
Animal	676	203	450	450	450	0
2 Irrigation	436	0	29	28	24	20
3 Fertilizer and pesticides	2 447	1 664	4 486	7 639	12 192	2 613
4 Seed	445	468	270	1 767	2 578	1 967
B Yield (kg/ha)	6 248	5 394	59 114	31 431	56 228	31 583
C Farm gate price (CNY/kg)	1.5	1.2	0.8	2.0	1.6	2.0
D Gross value of output (CNY)	9 372.0	6 472.8	47 291.2	62 862.0	89 964.8	63 166.0
E Net return (CNY/ha)	4 391	3 310	39 946	50 618	72 540	56 723

Table 5.8 Benefit-cost ratio of the production of different crops in 2012 in the Lucheba watershed in China

Particulars	Before	After
Rice	1.77	1.9
Maize/corn	1.26	2.0
Vegetables*	1.40	5.5
Watermelon	0.47	–
Pepper	–	5.1
Chilli	–	9.8

* Tomatoes, brinjal (egg plant), okra, etc.

has been rising since the initial phase of the watershed management development (Zhong Li *et al.*, 2005). Such an increase, particularly in the use of pesticides, must be monitored to assess the impact on the environment and human health, and to ensure sustainable and environmentally friendly agronomic practices. Farmers are using highly productive hybrid seeds for all the crops grown, and more than 60 percent of farmers attributed the adoption of new technology to the timely availability of hybrid seeds. Net returns from all vegetable crops are several times higher than for corn and rice (Table 5.7). Also, for chillies, cabbage, tomatoes and peppers, cost-benefit ratios are 1:9.8, 1:6.4, 1:5.2 and 1:5.1, respectively, which compares favourably with rice and corn's cost-benefit ratio of 1:1.9 and 1:2.0, respectively (Table 5.8).

5.3.6 Emerging market patterns

After watershed interventions, which resulted in a marketable surplus production of high-value vegetables, a mixed marketing pattern has emerged that is very different from the self-marketing method used in the past. Before effective watershed management, farmers were selling their produce of corn and rice in the village themselves. But the cultivation of vegetables has created new marketing channels and types of markets in the village (Table 5.9). Collective marketing through farmers' village associations (FVA) and middle men or agents are now major methods of selling produce – largely to semi-organized and unregulated markets using the Internet. It is important to note that with these Internet marketing facilities and assistance from FVAs, nearly 73.3 percent, 66.7 percent, 40.0 percent and

Table 5.9 Marketing patterns in 2012 in the Lucheba watershed in China

Name of the crop	Marketing mode (%)				Market type (%)			Total quantity sold (q)	Selling price (CNY/Kg)	Farmers who sold their production at expected price (%)	What marketing support will help you realize maximum revenue?
	Self	Collective	Middle men	Contract	Organized	Semi-organized	Unregulated				
Cabbage	0.0	40.0	56.7	0.0	0.0	63.3	63.3	4 033	0.8	66.7	Contract System
Pepper	0.0	40.0	20.0	0.0	0.0	60.0	60.0	537	1.9	40.0	
Tomato	0.0	40.0	56.7	0.0	0.0	60.0	60.0	1 821	1.6	73.3	
Corn	76.7	0.0	0.0	0.0	0.0	0.0	63.3	200	1.4	53.3	
Rice	76.7	0.0	0.0	0.0	0.0	0.0	63.3	198	1.6	4.8	
Chilli	0.0	63.0	36.7	0.0	0.0	60.0	0.0	399	2.7	36.7	

Table 5.10 Employment and income from farm and non-farm activities before and after the watershed management project in the Lucheba watershed in China

Sources	Units	Before project		After project		Percentage change	
		Number of units	Per unit cost	Number of units	Per unit cost	Number of units	Per unit cost
Casual village labour (farm work)	Work days	230	110.0	330	200	43.47	81.81
Casual village labour (non-farm work)	Days	1 330	677.5	300	990	-77.40	46.12
Income from migration	Work days	250	50.0	200	100	-20.00	100.00
Remittances (sent from family and relatives)		–	–	–	–	–	–
Sale from common property resources (CPRs)		–	–	–	–	–	–
Business net income (shops, trade, tailor, etc.)		–	–	–	–	–	–
Part-time job		–	–	–	–	–	–

Sale of CPRs includes firewood, fruits, etc.

Table 5.11 Gross income of farming households before and after the watershed management project in the Lucheba watershed in China

S. Number	Source of income	Before (CNY)	After (CNY)	Percentage change (%)
1	Crop	95 500	279 129	192
2	Livestock	51 000	0 ¹	-100
3	Non-farm	90 000	33 000	-63
	Total	236 500	312 129	32

36.7 percent of farmers producing tomatoes, cabbage, pepper and chillies, respectively, sold their produce at expected prices. However, in cases of rice and corn, 4.8 percent and 53.3 percent of farmers, respectively, received the expected price for their marketable surplus production. To minimize market risks, most of the sample farmers said they would prefer to carry out transactions using the new marketing systems (Table 5.9).

5.3.7 Employment and income from farm and non-farm activities

Integrated watershed management at Luchebe significantly improved food security and enhanced family incomes as was observed through tangible impact indicators of farm-based employment and income (Table 5.10 and 5.11). Diversification, using high-value vegetable crops, increased numbers of casual labour workdays by 43.47 percent with the labour force earning an increase of 81.81 percent. On the other hand, casual labour employment opportunities for non-farm activities fell by 77.4 percent, but earnings still rose 46.12 percent largely due to the increase in wages for non-farm activities in recent years. At the same time, migration reduced by 20 percent (Table 5.9). Farm income from crops, (largely vegetables), has increased by 192.30 percent whereas income from livestock and non-farm activities reduced by 100 percent and 63.3 percent respectively in the post watershed programme. Total income at the household level increased by 32 percent (Table 5.11). In Luchebe, per capita income in 2012 increased from CNY 6 800 per year in 2011 to CNY 8 100 per year, which was double the provincial average per capita income.

5.4 Conclusion and recommendations

An integrated watershed management approach has proved successful in improving the livelihoods of mountain people and providing better food security while ensuring sustainable environmental services and building the resilience of the food systems. If such systems are implemented on a wider scale, they could go a long way to helping achieve the target of Zero Hunger in mountainous regions.

Building integrated watershed systems through efficient rainwater management has enabled sustainable intensification of farming through diversification of systems with high-value crops. In addition, collective planning and new marketing methods using information-technology enabled services have benefitted small farmers, giving them improved scale of operation and better negotiating power with the market.

The success of the integrated watershed management and a value-chain approach is evident in Luchebe watershed where:

- ◆ By adopting an integrated watershed management approach through collectivization using a Farmers Association, water scarcity was overcome and enabled crop diversification with high-value crops.
- ◆ Per capita income (CNY 8 100 per year in 2012) was double the provincial per capita income.
- ◆ Cropping intensity increased 300 percent as the water availability was improved through *in-situ* and *ex-situ* management of rainwater in the watershed areas.
- ◆ High-value crops such as vegetables replaced the previously grown crops of rapeseed, rice and maize.
- ◆ A net present value (NPV) of USD 14.7 million was made over 10 years with an investment of USD 4.5 million.
- ◆ Many Future Smart Foods (FSF), which are climate resilient, locally grown, nutritious and are also good for the planet, can be grown in mountain areas, improving food security and helping to meet Zero Hunger.

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6 Integrated value-chain development of mountain products for poverty reduction and Zero Hunger

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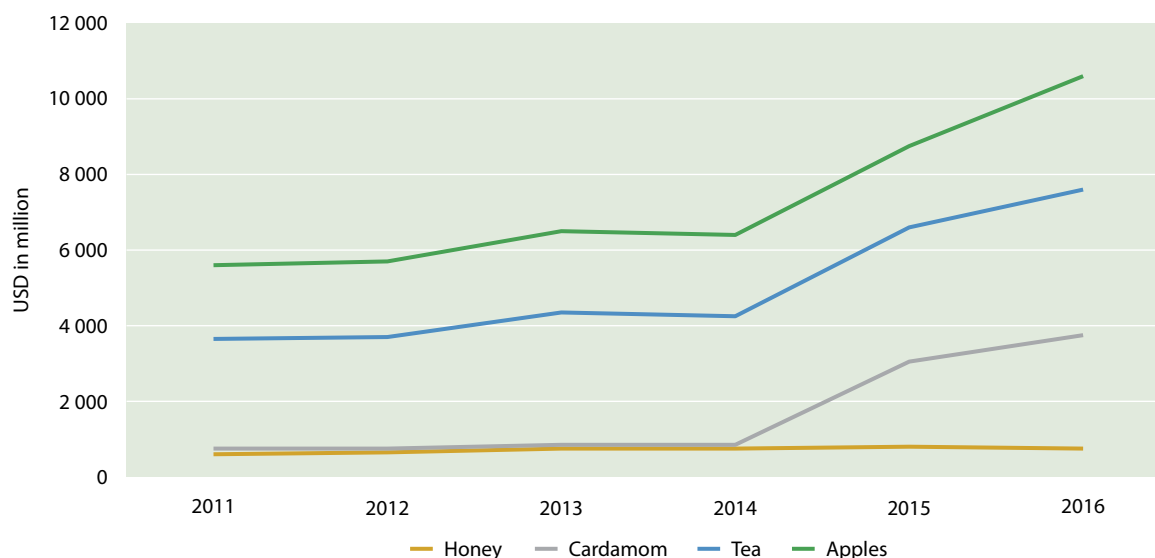
6.1 Introduction

A large proportion of the mountain population relies on climate-dependent sources of livelihoods, such as agriculture, livestock and forestry, and these are increasingly susceptible to climate risks, which potentially trigger outmigration and increase pressure on services in the destinations to which they migrate (Himalica, 2018). Mountains are important centres of agrobiodiversity with a great variety of locally adapted crops and livestock, and an important genetic resource and asset for assuring food security for a growing global population. However, mountain agricultural biodiversity is facing increased risk, and the number of crops and crop varieties grown on farms is diminishing (Banskota and Joshi, 2005). Declining diversity on the land coincides with increasing homogenization of diets. Today, 30 crops supply 95 percent of the calories that people obtain from food, and only four crops – maize, rice, wheat and potatoes – supply over 60 percent (FAO, 1999). This unprecedented and growing reliance on an increasingly narrow range of crops, crop varieties and animal breeds bring long-term risks for biodiversity. This situation leaves the food system unnecessarily exposed to shocks and stresses, as well as neglecting a high-impact solution to major health, environmental and food security challenges. The Intergovernmental Panel on Climate Change (IPCC) predicts that climate change will reduce agricultural production by 2 percent, while demand will increase by 14 percent every decade until 2050 (IPCC, 2014). The narrowing range of crops also undermines the ability of agriculture to adapt to climate change, because many traditional or indigenous local crop varieties and animal breeds are more resilient than the modern ones that have replaced them (IIED, 2018). Agricultural biodiversity and food security are strongly linked. Traditional cultivars are a source of nutritious food that are often disease resistant and adapted to variable local climatic conditions since they have an incredible

amount of genetic diversity. They can also provide characteristics and diversity that can be very useful for the further adaptation to climate change (Bioversity International, 2016; Maxted, 2006).

Although the great diversity afforded by specific conditions (biodiversity, climate, topography, culture) gives mountain areas a comparative advantage for producing a variety of ‘niche products’, the limited availability of arable land, and the smaller size and more fragmented farms make it difficult for mountain farmers to realize economies of scale. For example, the average farm size in Nepal is only about 0.7 ha per household and more than 50 percent of households have farms less than 0.5 ha in size. It is estimated that smallholder farmers owning less than 2 ha of land constitute about 85 percent of the total farmland globally, where the majority of these farmlands are in Asia (87 percent), with about 50 percent in China and 20 percent in India (Nagayets, 2005; FAO, 2001, 2004). Though these smallholder farmers are the source of more than 80 percent of food consumed in developing countries (IFAD, 2013), they often face challenges in accessing markets and fetching a good price for their produce (Joshi *et al.*, 2016).

The mountain farmers, unlike farmers from larger farms in the plains of the lowlands who are able to bargain and purchase more competitively, often get less value for their produce due to inadequate access to farm inputs, financial resources, technology, training, research and advisory services, and lack of basic infrastructure such as roads, transport, markets and communication (Joshi *et al.*, 2016). Considering the mountain context where producers are scattered, most of the produce is supplied in raw form, and a major share of profit margin is accrued at the upper end of the chain with little impact on poverty reduction and food security.

Figure 6.1 Export value of selected high value products in Hindu Kush Himalaya (HKH)

Source: FAOSTAT

On the one hand, there is a need to develop a value chain of mountain products and services, and, on the other hand, enabling and inclusive policy frameworks are required.

6.2 High-value mountain products: Market opportunities and challenges

For centuries, mountain communities have tapped into their natural resources and ancient expertise for producing high-quality and unique products such as coffee, cheese, grains, herbs, medicinal plants and spices as well as handicrafts. While small-scale mountain agriculture cannot compete with the volume of lowland production, it can focus on diversification and has the potential to tap into special niche markets such as organic, fair trade or high-end quality markets and in doing so, fetch premium prices.

The contribution of high value products to the economy of mountain area is very high. For example, the countries in HKH region earned over USD 10 billion from the export of apple, buckwheat, cardamom, nutmeg, mace, honey and tea in 2016. The recent trend shows positive growth in production volume and export value of these products (Figure 6.1).

There are some good examples of mountain people benefitting adequately from the resources they are endowed with, but majority of mountain people face number of challenges and obstacles including:

- ◆ lack of appropriate collection, processing, and marketing technologies;

- ◆ weak communication infrastructure, training, exposure, registration, certification and labelling mechanisms;
- ◆ inadequate marketing skills and lack of wider market access; and
- ◆ high transport costs.

Because of the terrain and microclimatic variation, mountain farmers cannot produce in large scale or volume, which makes it less lucrative for the private sector to bring processing and value-adding facilities closer to production pockets (Joshi *et al.*, 2016).

Many of high-value products and their health attributes are not well known to the consumers in the plains, and some of the traditional mountain crops (e.g. horse gram, sticky brown rice, amaranth, foxtail millet) are cultivated less often, due to the lack of appreciation of the different values associated with these crops (Banskota and Joshi, 2005). Consumers do not always distinguish mountain products (particularly those products which are also grown or produced in the plains, e.g. honey) from others when displayed in the marketplace. The cost of production of many such products are lower in the plains meaning that mountain farmers face increasing competition from products grown by large-hold farmers in the plains due to lack of effective traceability mechanisms for geographic origin (Joshi, 2015). For example, beekeepers in the plains can get 50–60 kg/colony/year from the European honeybee, whereas beekeepers in mountain areas hardly get 10–12 kg/colony/year from their native bees. Both types of honey look alike, but mountain honey contains unique ingredients that make it more hygienic and healthier to eat.

Table 6.1 Five key characteristics of resilient community

Characters	Characteristics of resilient community
Knowledgeable	Has the ability to assess, manage and monitor risks, and can plan to address risks
Organized	Has the structure (e.g. management committee, cooperative) and capacity to collectively set priorities, make decisions and act upon them
Connected	Has relationship with local governments and other external actors, who provide a wider supportive environment and supply goods and services when needed
Economic opportunities	Has diversified income sources and employment opportunities, access to financial and other business development services for enterprise and value chain development
Natural assets	Recognizes the value of natural resources and has skills and ability to maintain, protect and utilize natural assets

With a shift in food consumption patterns (i.e. a dietary shift away from cereals towards meat and vegetables), the agribusiness environment is becoming volatile. The demand for 'safe and hygienic food' is on the rise and there has been a shift from product to process standards. While inspection of produce, particularly at points of export and import, remains an important part of the food safety system, there is growing concern about the processes and systems that exist in the country of origin. For example, for Nepalese honey to be sold in the European market, it is not sufficient that the honey samples pass tests that show they possess no threats to human safety. The country itself first needs to be listed as an eligible country for exporting honey to the European Union (EU) based on assessment of residue monitoring and quality control systems (Joshi, 2008). The introduction of systems, such as Hazard Analysis and Critical Control Points (HACCP), requires new systems to be established and verified, which imposes additional costs. A second challenge relates to certification that is appropriate for small producers.

Meeting the market requirements for agribusiness products has become more challenging in recent years for three reasons:

- 1 satisfying food safety requirements and compliance with standards;
- 2 satisfying requirements of demanding buyers in terms of large volume, speed and reliability of delivery, and customization of products; and
- 3 maintaining the identity and distinctiveness of the product as it moves along the value chain.

Considering that mountain agriculture is highly diverse, small-scale and inherently green, the Mountain Partnership Products Initiative (MPP Initiative) and other organizations such as the ICIMOD strive to create demand for high-quality traditional mountain products,

harness comparative advantages and create fair incentives/compensation for mountain farmers, particularly for women, who are often left to manage the farms and households as men migrate to lowland areas in search of additional sources of income. An increased demand for traditional mountain products can increase their income through trade and manufacturing. In this chapter, an approach is laid out for creating shared value through improved value-chain development.

6.3 Integrated value-chain development approach

The integrated value-chain development approach is a market driven systems approach, which focuses on linking households and/or communities to growing markets, so that they can earn income to purchase additional food while reducing the risks that come with relying solely on their own production. This will be done by striking the right balance between improving productivity while ensuring market functionality and sustainability. It emphasizes specific opportunities (e.g. the comparative and competitive advantages of mountain products and services) and challenges to achieving sustainable and inclusive growth.

The generic value-chain approach focuses mainly on improving the competitiveness of targeted commodities by ensuring quality control from production to post-harvest handling (grading, processing, packaging and storage), marketing and distribution, and consumption. However, the integrated value-chain approach puts emphasis on building the resilience of production systems by promoting climate-smart practices and livelihood diversification through improving access to finance and other business development services, including post-harvest handling and enterprise/entrepreneurship development.

Box 6.1 Case study on the e-commerce development of agricultural products in China

According to data published by China's Ministry of Commerce, the online retail sales of physical commodities in 2018 was USD 1.06 trillion, an increase of 25.4 percent over the previous year. Of this, the value of agricultural products was USD 34.8 billion, representing a 33.8 percent year-on-year growth. According to data from 2018, agricultural products accounted for only 3.3 percent of total retail sales of physical commodities. Even so, because of the huge growth of online sales of agricultural products, the proportion of online retail sales of such products will be higher in the future. Traditionally, due to low prices, the difficulty in standardization, short preservation times (agricultural products perish quickly), and other characteristics, agricultural products have not been the natural choice for online sales, especially when compared with what are known as 3C products: computers, communication and consumer electronics. But as China's economy is currently slowing down and the consumption of manufactured goods has nearly reached saturation point, the e-commerce sector has begun to pay closer attention to the potential of agricultural products. In addition, the Chinese Government is looking at e-commerce as a way of fighting poverty in the nation. Under the guidance of the Ministry of Commerce, the China e-commerce Poverty Alleviation Alliance was established by 28 corporations and covers 351 poorer counties that could benefit.

The most direct benefit of e-commerce for agricultural products is the way that it can modernize traditional ways of selling and marketing, and create connections between farmers and the customers who want their products.

In October 2017, Jinzhai County in Anhui Province signed a Memorandum of Poverty Alleviation for the Jinzhai kiwi fruit Industry with the World Food Programme (WFP) and Alibaba Group. The memorandum was aimed at building a 300 mu¹ Kiwi Fruit Poverty Alleviation Demonstration Base. By the terms of the agreement, WFP provides support of CNY 10 000 per mu, which was designated as pay for the labour of people from some 200 poor households.

Alibaba helped create standards for the production, storage and marketing of the kiwi fruit. They established a system of central storage, developed quality standards and inspections, and set up supply chains for product delivery. Alibaba also helped brand the fruit as *TaoYum* giving it an identity in the marketplace. By the end of the process, there was a full industrial supply chain in operation, from the planting of the kiwi trees through to selling and distribution. This helped raise the incomes of local people and reduce poverty.

E-commerce for agricultural products also helps promote agricultural production in local areas or nearby towns. This gives rural women more employment opportunities, while helping to protect the environment and ensure that resources are used sustainably. For example, until just 10 years ago, the "slash-and-burn cultivation" method of farming was still used in more remote areas of China. But with the introduction of e-commerce, consumers started paying more attention to where products come from and how they are produced. This has led to communities understanding the benefits of using more sustainable production practices, which attract more buyers. It also corresponds to a more heightened awareness of environmental protection, as summarized in the assertion of President Xi Jinping that "lucid waters and lush mountains are invaluable assets".

Another benefit of e-commerce for the people of Jinzhai County is that the producers now get a higher price for their produce through online selling. And with word spreading, more tourists are visiting the region to enjoy the natural area. There is also a better balance between people and nature.

So the results of e-commerce for Chinese agriculture, while still at an early stage, are highly encouraging. There are still areas for improvement in areas such as stock keeping, traceability, quality inspections, distribution and delivery and supply chains etc. But by continuing to explore the many benefits of e-commerce, there is greater hope for millions of people in rural China. This is beautifully summed up in the famous Chinese saying, "tomorrow will be better."

In this approach, the interventions are designed based on climate-change risk and vulnerability assessments and a detailed diagnosis of value-chain needs for high-value products. With the understanding of the root causes that block the development of value chains, opportunities are being explored to bring in innovations (going through different stages/finding different ways of doing things) to build new relationships and facilitate

upgrading value chains in terms of process, function and product improvements.

The value-chain interventions focus on five characteristics of resilience building (Table 6.1). The first step is to sensitize communities and raise their awareness and ability for assessing, managing and monitoring risks at the local level. The facilitation

¹ Mou, Chinese unit of land measurement that varies with location but is commonly 806.65 square yards (0.165 acre, or 666.5 square metres).

Figure 6.2 Model for integrated value chain development of large cardamom

support provided would help to develop community-led micro-plans and strengthen their relationship with local governments and service providers for addressing socio-ecological and climate-change risks. Simultaneously, community members would be encouraged to form groups/cooperatives and committees (e.g. a seed bank management committee) for setting up common priorities and collective negotiation.

A number of trainings and support activities are provided on business planning, and enterprise development for enhancing capacity in order to maintain and provide services at the local level (e.g. bulk purchase of produce from farmers' groups to supply products to high-end markets, or the establishment of common facilitation centres to help farmers in various operations). It is also important to

link value chains with wider ecosystems by conducting participatory multi-dimensional ecosystem assessments.

This helps communities to better recognize the value of their natural assets and make judicious and sustainable use of resources (e.g. sustainable land management, sustainable use of water resources, control of free grazing along with the protection of natural forest, use of improved cook stoves and planting of fodder trees). As income is essential for improving livelihoods, coping with risks and getting better prepared for shocks are of the utmost importance for increasing and diversifying income by upgrading different stages of the value chain.

With improving access to telecommunication and Internet services, there is good scope to share real-time weather information and forecasts, market prices and technical advice on crop management among mountain

communities. Efforts are being made in mountain areas to connect farmers with market outlets and actors using digital services (interactive voice recording systems, SMS, toll-free calls, and social media groups). E-commerce is also gaining popularity as a tool for marketing agricultural products in many countries. For example, in China there are some innovative e-commerce models such as “social e-commerce”, and *Tik Tok* – a media app for creating and sharing short videos – that have brought about many positive effects, which include responsible production, environmental protection and sustainable development. The experience from China suggests that with the introduction of e-commerce, consumers would care about not only the quality of products themselves, but also the production process and environment. Farmers also found that mountain products, which are seen as organic have environmentally friendly image that attracts consumers and that by using greener technologies they will enjoy many other benefits. Box 6.1 presents the importance of e-commerce development to agriculture products of China in general. With increased access to digital services and smartphones, there is great potential for e-commerce development to mountain products in other countries as well.

6.4 A case study on integrated value-chain development of large cardamom pods in Nepal

ICIMOD, under the EU-funded Himalica Programme, implemented a pilot project together with local partners in Taplejung, Nepal with the aim of providing multiple benefits that can and improve the livelihoods and incomes of the mountain communities while exposing them to fewer risks. As well as strengthening the existing value chains of large cardamom pods, the project interventions focus on building resilience through diversification of products, processes and functions (Figure 6.2).

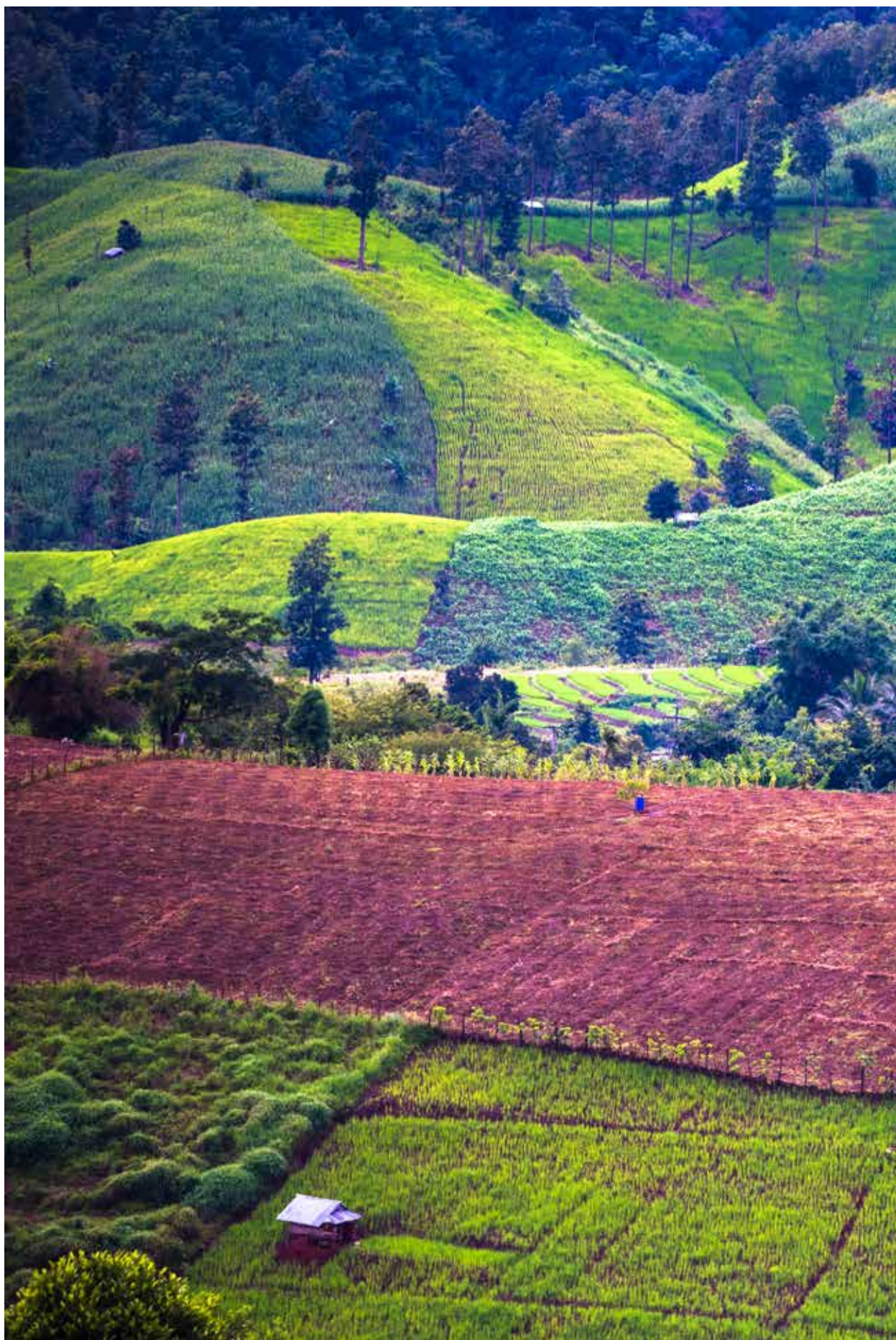
Promotion of climate-resilient practices: The Himalica Programme has built up good practices from the cardamom growing areas of HKH region, and developed a “Package of Practices” (POP) focusing on six elements of climate resilient agriculture: weather, soil/nutrients, water, energy, knowledge management, and gender integration as a cross-cutting element. POP brings innovative features for augmenting livelihoods with sustainable resource management. The practices are showcased in farmers’ fields to improve and adapt large cardamom production systems to climate change (which is predicted to bring longer dry spells, more erratic rainfall, and increased pest and disease

infestations). As per the end line assessment report, every household in the pilot site has adopted at least one element of the POP. As an outcome, yields of dry cardamom capsules were reported to have increased by about 75 percent in the demonstration farms in comparison to conventional farms.

As a part of POP, the pilot project has also promoted integration of other farming options such as beekeeping, shitake mushroom, vegetable farming and kiwi farming to reduce the risks and further strengthen the resilience of farming households.

Value addition and product development: Most farmers in Taplejung sell large cardamom pods to local traders and face challenges due to production and price fluctuations. To overcome these challenges and to provide more diverse livelihood options, the Himalica Programme has partnered with the social enterprise SAARC Association for Home-based Workers or SABAH Nepal to build the capacities of interested community members to make value-added products from cardamom pods, such as cardamom powder, cardamom biryani masala, and cardamom tea mix. Traditionally, the cardamom stems are just left in the fields, but with training and exposure a few entrepreneurs started using them to produce cardamom fibre to weave a range of products (e.g. table runners, dining mats, etc.).

The Kanchenjunga Himalica Agriculture Enterprise (KHAE) is registered in Taplejung, and has set up a fully equipped production centre for grading, processing and developing cardamom-based products. The value-added products are being marketed under the brand and tag “HIMALICA–Green Products from the Mountains”. The Koseli Ghar or Himalica Community Gift House, a retail outlet for marketing of value-added products at the local level, has been also set up in Phungling Bazaar in Taplejung giving farmers a new marketing outlet for their products. With SABAH’s support, cardamom is being promoted as the Queen of Spices in Kathmandu and other markets. And enterprise is not limited to value-added cardamom products. Selected farmers and potential entrepreneurs also have been trained technically and supported financially to develop products, such as pickles, jam and squash from locally available fruits, herbs and spices. As part of risk reduction strategies, Himalica also supported ICT-assisted Spice Garden Tourism, in partnership with the Nepal Tourism Board (NTB), the Trekking Agencies’ Association of Nepal (TAAN), Wolfmatrix and the Environment Conservation and Development Forum (ECDF). A few community members, particularly young people, have been given experience and training in homestay tourism and



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Brief summary of climate smart practices

- ◆ Weather-smart practices, which include alteration of planting time and the planting of recommended local varieties that are resilient to extreme weather conditions, assessment of rainfall requirements, snowfall and frostbite in cardamom and measures to cope with these problems.
- ◆ Soil/nutrient-smart practices, which include production and application of manures, compost production, green manure, intercropping, weeding, etc. to maintain soil health/organic matter.
- ◆ Knowledge-smart practices, which focus on strengthening market linkages and making market price, weather, and good practice information and extension services available to farmers and value chain actors through mobile messaging, including information on soil type, slopes/aspects, disease and pest management, demand-supply, and business development services
- ◆ Water-smart practices, which focus on effective and efficient use of water, demonstrating technologies that farmers should apply to ensure water use efficiency and water availability – modern irrigation systems, soil moisture conservation through mulching, shade, rain water harvesting/ponds, etc.
- ◆ Energy-smart practices, particularly use of energy efficient dryers, and renewable technologies such as microhydel for drying and grinding cardamom
- ◆ Gender-smart practices, particularly promotion of gender-friendly technologies and good practices that result in increased productivity and reduced drudgery for women and children.

hospitality management as well as trekking guide training. They are now being supported to operate homestays in three clusters.

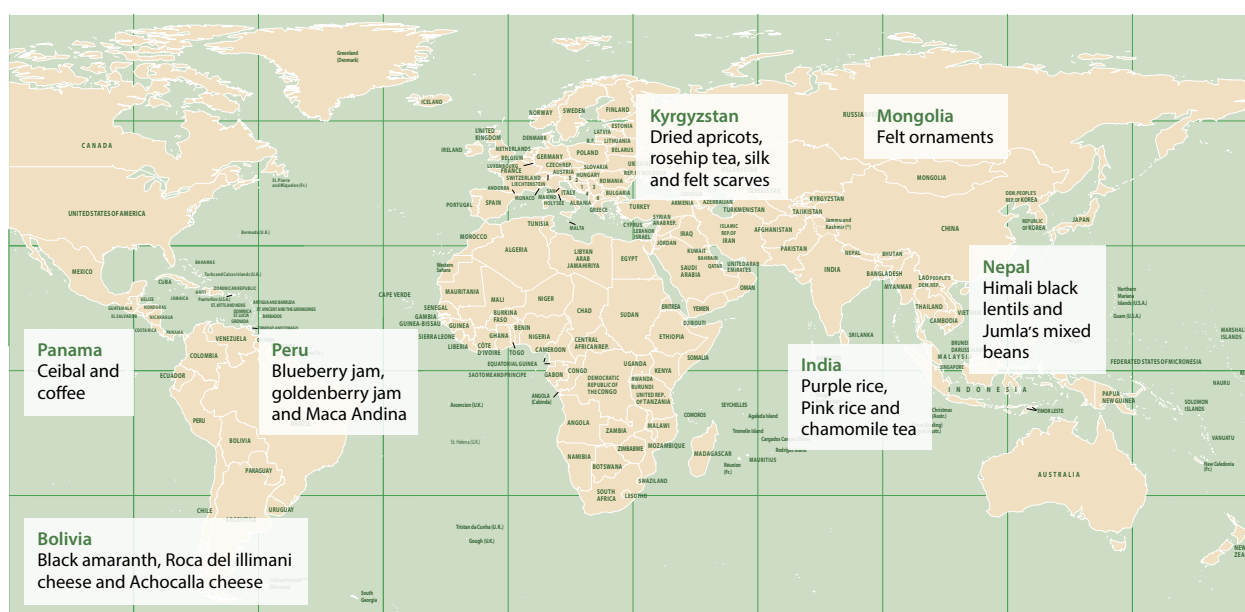
Access to information and support services: The Himalica Programme places high emphasis on the strengthening of institutional links, community mobilization and capacity building for ensuring the sustainability of interventions. Through ICT-based services, the cardamom producers in Taplejung are able to access real-time market price information, agriculture extension information, and weather information. A total of 220 registered farmers and users from Phungling, Sikaicha, and Furumbu now receive Nepalese language SMS messages almost every day. They find the service useful, as it helps them better plan production and sales, and reduces their reliance on local traders for cardamom price information. The farmers are also consulting cardamom experts to address their issues through interactive messaging and bi-weekly “Call the Expert” services offered in collaboration with research scientists from the Cardamom Development Centre, Fikkal, Ilam and the National Agriculture Research Council (NARC), Pakhribas, Dhankuta. The Nepal Cardamom Entrepreneurs Association intends to extend this service to all their district chapters in Nepal.

Community-led micro-plans and ownership of local government: With facilitation support from the Himalica Programme, community groups were tasked with making thorough assessments of potential risks and vulnerabilities both at the household and ecosystem levels. The groups then had to come up with microplans

to minimize the risks and improve their adaptive capacities. The issues from the field were communicated with the local government and line departments of the ministries using various platforms. Resources of the local government are being leveraged for increased uptake of demonstrated technologies and practices. Recognizing the effects of interventions and innovativeness of the Himalica pilot, the newly elected representatives of the municipality solicited support from Himalica to formulate a Five-Year Strategic Action Plan and a Vision for Agriculture Development. The plan has been developed taking into reference the national vision and action as reflected in the Agriculture Development Strategy.

As per comparative assessment of baseline and end line surveys, the beneficiary households were found to be less affected by price falls than the project’s non-beneficiary households. The production of cardamom and sales/income from this crop was found to increase in the treatment group after intervention. For example, the beneficiary households, on an average, produced 53 kg more after the programme intervention, which translates into earnings of around NRS 91 000 per annum more than the treatment group. The assessment report revealed that every beneficiary household in the pilot site has adopted at least one element of POP, and also found that the plots where manure/mulching and other recommended practices were applied produced more cardamom with 750 gm dried capsules per clump, as compared to conventional farms that gave only 350 gm dried capsules per clump.

Figure 6.3 In phase one (2015–2017) 16 products from seven countries were granted the Mountain Partnership Products label



Source: Mountain Partnership Secretariat

6.5 The Mountain Partnership Products Initiative

To support small mountain producers and the development of mountain economies in developing countries, Mountain Partnership² and Slow Food International have jointly developed a global participatory certification and voluntary labelling scheme for mountain products. In 2015, the MPP Initiative was launched to promote sustainable food systems, agro-biodiversity and innovation in mountain areas to add value to traditional farming systems. The initiative supports smallholder mountain producers in developing countries through value-chain improvement, marketing strategy development and the granting of the Mountain Partnership Product (MPP) label to selected high-value mountain products, while developing the capacity of producers to improve the quality, marketing and distribution of their products, while preserving their traditional knowledge.

The MPP label is a narrative label that tells the story of a specific product and highlights what makes the product unique by providing information that is not

included in a typical commercial label to engage and inform consumers. This label communicates the main qualities of the product, including its origin and nutritional elements, and the ethical values of its processing. This allows consumers to look beyond the product and to make a more informed choice and thus allow small producers to obtain fair compensation for their products. Furthermore, it integrates, but does not replace, any existing label mandatory by law in any country.

In order to obtain the label, products must comply the four eligibility criteria, which address:

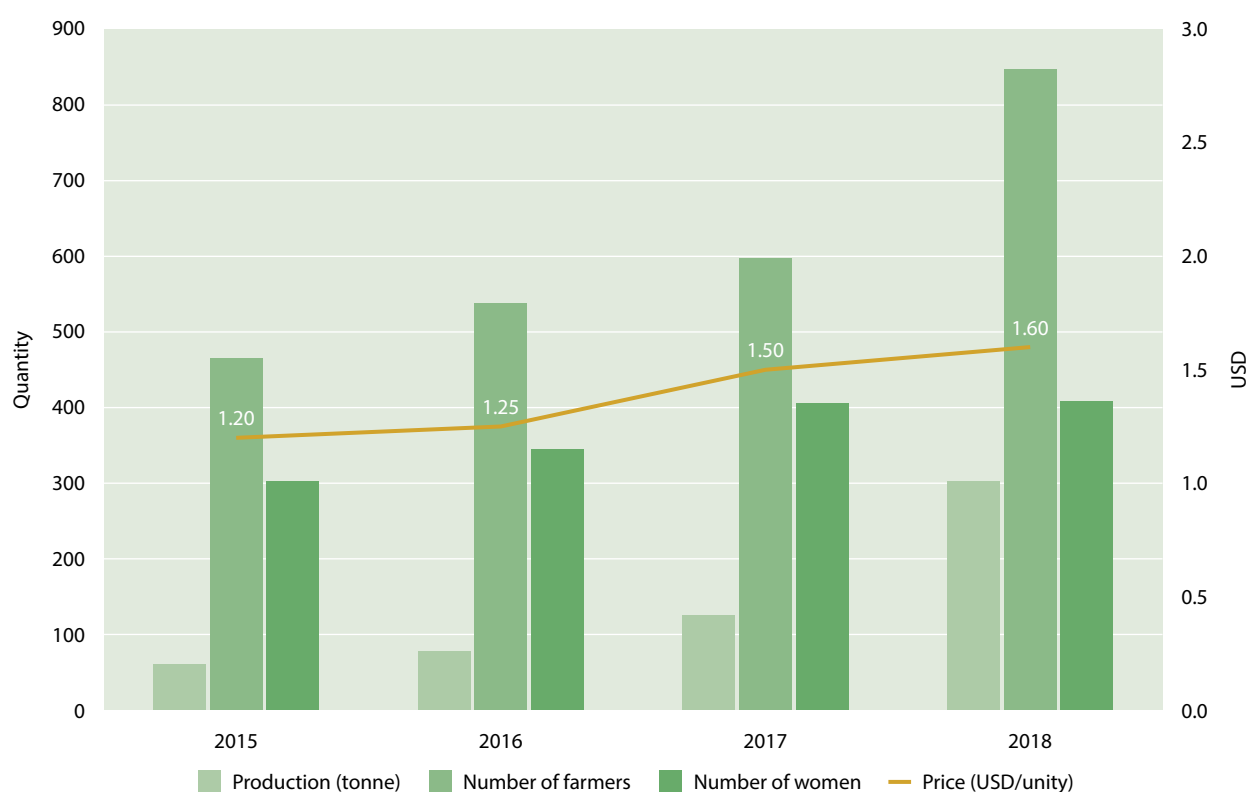
- ◆ Altitude – Products have to be mainly produced and transformed in mountain areas:³
- ◆ Environmental sustainability – production processes have to be respectful of the environment.
- ◆ Equity – fair returns for the producer and equitable distribution of profits along the value chain.

² Mountain Partnership is a United Nations voluntary alliance of partners dedicated to improving the lives of mountain peoples and protecting mountain environments around the world. It was founded in 2002, and, as of 2018 has over 340 members, including governments, intergovernmental agencies, organizations and civil society.

³ The definition of mountains used is the UNEP-WCMC, often referred to as Kapos, that indicates six elevation classes according to the following scheme:

- ◆ Class 1: elevation $\geq 4\,500$ m
- ◆ Class 2: elevation 3 500–4 500 m
- ◆ Class 3: elevation 2 500–3 500 m
- ◆ Class 4: elevation 1 500–2 500 m and slope $\geq 2^\circ$
- ◆ Class 5: elevation 1 000–1 500 m and slope $\geq 5^\circ$ or Local elevation Radius (LER) > 300 m
- ◆ Class 6: elevation 300–1 000 m and LER > 300 m

Figure 6.4 Development of price, production, number of farmers and women of Jumla's mixed beans, Nepal since joining the Mountain Partnership Products initiative and receiving the label in 2016



Source: Mountain Partnership Secretariat

Figure 6.5 In 2018 400 Female producers are cultivating Jumla's mixed beans in Nepal and could benefit from a price increase of 20 percent as a result of the Mountain Partnership Product label



Source: Organic World and Fair Future Pvt Ltd.

- ◆ Small-scale production,⁴ – including family farming, small mountain producers, women farmers, cooperatives and producers' organizations.

The details on product labels are available on the Mountain Partnership website (www.fao.org/mountain-partnership). In its first phase of this pilot project 16 products from seven countries have been selected (Figure 6.3). Products range from coffee produced in the Panamanian Central Cordillera to herbal tea and rice grown in the Indian Himalayas.

Jumla's Mixed Beans, Nepal

One of the MPP labels is Jumla's mixed beans, which are a traditional mixture of black, red, yellow and spotted beans (Figure 6.4). They are cultivated by Bhote Lama and Brhamin farmers at an altitude of 2 300 metres above sea level in the Sinja Valley, Jumla District – one of the most remote mountain areas in the north-western part of Nepal. Local farmers still cultivate the beans manually without mechanical inputs, resulting in high-quality but low-quantity production. The beans are closely tied to the local culture and religious festivals like *Janai purne*, marking the end of the rainy months and beginning of the cold season. In spite of their traditional and environmentally friendly production process, Jumla's mixed beans are under the threat of being replaced by more productive crops.

⁴ Smallholders are small-scale farmers, pastoralists, forest keepers and fishers who manage areas varying from less than one hectare to 10 hectares. Smallholders are characterized by family-focused motives, such as favouring the stability of the farm household system, using mainly family labour for production and using part of the produce for family consumption (FAO 2012).

Since joining the MPP Initiative in 2016, farmers' livelihoods have been transformed. Jumla's bean production has doubled in the past three years, thanks to better marketing and distribution of the high-quality product, while the market price for the beans has risen by 20 percent. The MPP label added NPR 10 per kg to the profit of farmers. The success of the label has also attracted 13 percent more women as farmers in the same period.

The MPP label not only helped fetch better prices and fight against imitations, but it also became a source of pride for farmers to receive an upgrade of their product, as the label contributes to protecting food heritage of the Himalayan villages in a responsible manner. Because of the MPP label, the marketability at local and national levels has been increased, and the pulses are sold in a large supermarket chain.

6.6 Conclusion

Poverty and food insecurity are closely linked concepts that overlap. It is thought that hunger is the result of poverty, but hunger can also be a cause of poverty (Dahal *et al.*, 2010). As agriculture remains an important base from which poor households seek to diversify their livelihood portfolios and improve their lives, it is widely agreed that increasing production and export of agricultural products is an effective way to improve livelihoods and kick-start growth (DFID, 2002). Mountain products have a key role to play in sustainable food systems and improving livelihoods. Not only do they contribute to food security and sustainable food diets, but they are a means of improving local economies, livelihoods, preserving agro-biodiversity and maintaining the uniqueness of mountain peoples' heritage and culture that has been developed over the centuries.

ICIMOD's interventions on large cardamom pods demonstrated that integrated value-chain development approach can contribute to reducing poverty and contribute to helping reach zero hunger, thereby creating shared value through strengthening producers and their groups and organizations to acquire agricultural inputs collectively at lower prices, and helping them to add value and commercialize their products. The success of the Himalica Programme intervention in the cardamom value chain resulted in almost 2 100 community members being trained, with 36 percent women in various aspects of climate-resilient agriculture, and 12 students from beneficiary households supported to pursue a vocational training

course. A total of 21 smokeless drying facilities were installed that produced 5 680 kg of value-added cardamom, and 12 farmers groups registered under the agriculture development office. In addition, the business development-diversification support created dozens of microenterprises based on making and selling cardamom-fibre woven products.

The approach adopted by Himalica is innovative and replicable, not only to overcome key constraints in the cardamom value chain, but also can be applied in any value chains across the HKH region. The technologies and practices, which have been showcased in demonstration plots, are simple and affordable, therefore, they have good potential for up-scaling in other districts of Nepal as well as in Bhutan and Sikkim in northeast India, particularly in areas considered suitable for large cardamom farming. POP is not prescriptive but co-developed and contextualized. It includes technologies and practices that are low cost, simple, easy to maintain and operate, and replicable in partnership with the private sector, government line agencies and other relevant stakeholders in any region of the world with similar agroclimatic zones where people are dependent on agroforestry and high-value crops.

Building on the rising consumer demand for high-quality, traditional products, the Mountain Partnership Secretariat has promoted a project to ensure that producers can receive fair compensation for their work, consumers can recognize mountain products in the marketplace, and traditional products and techniques can be preserved. The MPP Initiative reveals that labelling mountain products can boost the incomes of mountain peoples. It highlights that even a simple but innovative tool, such as a narrative label, which describes the story of a product and the producers, can have a considerable impact on local livelihoods.

In its first phase (2015–2017), 16 products from seven countries have been selected and over 24 producers' organizations (representing at least 240 families) with a high percentage of women have so far been benefitting from this scheme. The scheme improved livelihoods for mountain farmers, increased recognition of the high value and potential of selected mountain products, strengthened value chains for high-value mountain products and expanded market opportunities. Furthermore, capacities of producers and institutions focusing on technical, entrepreneurial and marketing topics have been enhanced. Training included product quality and sustainability improvement, certification and

labelling strategies, and marketing approaches, which will also contribute to the protection of the rich mountain biodiversity.

In its second phase (2018–2019) the MPP Initiative aims to expand to other countries, and efforts are underway to adopt a standard assessment and monitoring methodology. The methodology chosen for such a purpose is the Participatory Guarantee System (PGS) developed by IFOAM-Organics International, already applied in many countries around the world as a valid means to certify organic, ecological and agro-ecological producers for local and domestic markets.

Further, the MPP scheme aims to expand the scope of its initiative and to turn into services. The new pilot scheme on food and tourism is being developed with the aim of promoting links between high-quality mountain products and ecotourism services.

Climate services, innovative web portals and e-commerce offer good prospects for linking mountain farmers and smallholders with markets, thereby creating simultaneous benefit to people and nature. The e-commerce experience of China has potential to be replicated and customised for use in other countries.

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7 Globally Important Agricultural Heritage Systems (GIAHS) and their role in integrated mountain agricultural development

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7.1 About GIAHS

7.1.1 The concept of GIAHS

In 2002 in order to face the challenges of the degradation of agricultural ecosystem function, biodiversity loss and other global issues, the Global Environment Facility (GEF) and other international organizations including the Food and Agriculture Organization of the United Nations (FAO), started an initiative of Globally Important Agricultural Heritage Systems (GIAHS) that emphasized dynamic conservation ideas. FAO defined GIAHS as “remarkable land-use systems and landscapes rich in globally significant biological diversity evolving from the co-adaptation of a community with its environment, needs and aspirations for sustainable development”. The GIAHS initiative is aimed at establishing the basis for international recognition, dynamic conservation and sustainable development management of such systems as agricultural biodiversity, cultural biodiversity, knowledge systems, food and livelihood security, landscapes and social relations (Altieri and Koohafkan, 2004). Since then, an increasing number of countries and international organizations have endorsed the concept of GIAHS and have committed to the related dynamic conservation techniques. As of March 2019, 57 traditional agricultural systems from 21 countries have been designated as GIAHS sites.

7.1.2 The multi-functionality of GIAHS

Among the many characteristics of these GIAHS sites, multifunctionality is perhaps the most important for their conservation and development.

Multifunctionality of agriculture (MFA) refers to the idea that agriculture has a bigger role to play than the simple production of food or cloth. It can help with renewable

resources management, biodiversity conservation and the socioeconomic viability of regions, as well as help educate stakeholders and preserve local cultures. (OECD, 2001). Agricultural multifunctionality can be the basis for the development of other related industries (Knickel and Renting, 2000).

Of course, crop production has always been the fundamental to agriculture throughout human history but GIAHS bring these other elements into play. FAO's own definition of GIAHS lists five main functions of agriculture in GIAHS sites: livelihood functions, landscape conservation, agrobiodiversity conservation, traditional knowledge and culture inheritance and ecosystem services (Table 7.1).

GIAHS are generally located in the areas with relatively poor cultivated land resources, which mean low yields and less cultivated land per capita. At the same time, agricultural production in GIAHS relies mainly on traditional tools and methods and rarely uses modern agricultural technology and equipment. Agricultural productivity is therefore low and agricultural input and output markets are not well developed. This means that the crop production function of GIAHS have traditionally focused on providing enough food crops for general consumption by farm households. However, the yield of GIAHS tends to be stable even when there are extreme weather events and this means that surplus produce can be grown.

Agricultural landscapes are semi-natural cultural landscapes formed by both human activity and natural processes. And of course, while the primary function of such landscapes is agricultural, the symbiosis between a landscape which is both lived in and worked upon and where people are actively managing natural resources, means that GIAHS can be enjoyed aesthetically as well as

Table 7.1 Five main functions of agriculture in GIAHS sites

Crop production	landscape conservation	agrobiodiversity conservation	traditional knowledge and culture inheritance	ecological functions
<ul style="list-style-type: none"> ◆ To provide various food and nutrition ◆ To provide other products ◆ Source of incomes ◆ employment 	<ul style="list-style-type: none"> ◆ Land use structure ◆ Water and soil management ◆ Farmland structure ◆ Adaptive building structure 	<ul style="list-style-type: none"> ◆ Diversity of crop varieties ◆ Gene diversity ◆ Related species diversity 	<ul style="list-style-type: none"> ◆ Indigenous knowledge ◆ Cropping systems ◆ Agricultural technologies and skills ◆ Traditional management systems 	<ul style="list-style-type: none"> ◆ Clean water ◆ Green Agricultural Products ◆ Livable environment

practically. Indeed, such regions have long been a source of inspiration for artists and photographers as well a huge attraction for tourists.

One of the salient features of GIAHS is their high degree of agrobiodiversity. This great diversity includes the genetic resources of both plant and animal species, which have been built up over centuries. This is because by planting several species and varieties of crops, farmers minimize the risk of catastrophic loss and can stabilize yields over the long term. This diversity of crop and livestock also allows farmers to maximize returns, even with low levels of technology and limited resources. One result of this type of farming is the preservation of landraces in GIAHS sites. There are two main benefits to the conservation of landraces in GIAHS sites. The cultivation of more diverse local varieties reduces the vulnerability of crops to epidemics of biotic stresses of plant disease and pests to abiotic stresses of drought and extreme temperatures while protecting against genetic erosion.

The local varieties planted in GIAHS sites are like a savings bank of genetic resources *in situ* as well as the evolutionary processes that generate them, both known and unknown. Maintaining these important resources *in situ* can benefit future generations of farmers and society as a whole.

Agricultural development is, by definition, mutually linked with cultural development, expressed in the development of skills and knowledge related to the utilization of the landscape resources, in handicrafts, buildings, music and stories. Much of the traditional ecological and agricultural knowledge systems that underlie GIAHS and the ways farmers adapt and cope with the changing environment and socio-economic conditions have proved invaluable to local internal and external aid assisting poor farmers in many parts of the globe in restoring the ecological integrity of microwatersheds and the productive capacities of small

holder/traditional family farming communities. The preservation of this traditional knowledge and culture contributes to the preservation of cultural diversity in different parts of the world.

The final function of GIAHS is to reduce the more negative impacts of agriculture on the land. After all, in every country, agriculture and related land use can have both beneficial and harmful effects on the environment. Among the negative impacts of agricultural production are nutrient runoff, erosion, and pollution from the use of pesticides and herbicides. However, the low chemical inputs of GIAHS and the overall ecological principles enable production systems to be self-sustaining without the use of pesticides and chemical fertilizers. This aspect of GIAHS is especially important in these ecologically sensitive areas, as they ensure better environmental protection and improved long-term sustainable management of natural resources.

GIAHS can have other positive affects on the local environment, through the use of ancient farming methods such as the rice-carp symbiosis, mulberry dike and fish ponds, and agroforestry.

Agricultural functions can easily divided into two separate, yet strongly linked entities. The first is direct supply, which involves the sale of growth and sale of agricultural products, such as food products. Direct supply can also include accommodation services and the recreational activities that many farming regions offer. So direct supply has productive, economic and social functions. The second is indirect supply, which involves preservation and cultivation of the landscape and traditional agriculture, which acts as a backdrop or as a tourism resource. If farmers produce positive externalities, resulting in attractive landscapes and an appealing environment, this will have a positive influence on the demand for rural tourism. So indirect supply concerns the ecological and cultural functions of a landscape.

7.2 Mountainous areas: Intensive GIAHS or potential Sites

7.2.1 Traditional and ingenious agricultural practices in mountainous areas

In agricultural terms, most mountain areas are considered marginal land, unsuitable for modern farming, which usually focuses on the cultivation of a single crop variety for large markets. Although a growing number of mountain farmers have adopted modern farming methods, many indigenous men and women continue to cultivate using traditional practices and techniques such as terracing systems (rain-fed or irrigated), traditional cultivation using animal power, water transportation and flood irrigation schemes, and a combination of crops, pasture, forestry and farming. In this way, they farm a wide variety of crops that are adapted to a range of different elevations, slope conditions and microclimates.

Wet crops, dryland crops, trees, fish, poultry and livestock are the main agricultural products in traditional systems and so are important to livelihoods and as a source of human nutrition. In many cases, farming income can be supplemented by forage for wild produce, handicraft production and tourism.

Mountain agriculture not only constitutes a major occupation and source of sustenance for the majority of mountain communities, but also represents a primary form of natural resource use in mountain areas of developing and developed countries, including China and Japan. Therefore, indigenous mountain people and other traditional mountain communities serve as custodians of traditional knowledge about farming in difficult mountainous terrains which are important reservoirs of agricultural biodiversity. It is these unique characteristics of mountain agriculture that make mountain regions an important target of the GIAHS initiative. Developing mountain agriculture is a huge part of the project.

Some 60 percent of the world's designated GIAHS sites are located in mountainous areas, and the proportion remains the same for China. Table 7.2 shows some typical GIAHS sites in mountainous areas in both developed and developing nations. The harsh geographical conditions mean that infrastructure construction in these areas tends to lag behind, and the basic public services such as education and health services are seriously deficient in quality and quantity. Young and middle-aged people in poverty-stricken areas lack necessary labour and technical training and often only engage in simple physical labour. What's more,

the opportunities for self-development are severely lacking in mountain areas.

In addition, according to the major function-oriented zone planning, there is great correlation between concentrated contiguous poverty areas and the distribution of important ecological functional areas in China. It is clear that some of the poorest areas of China are the richest in terms of ecological biodiversity. This includes wetland protection areas, desertification control areas, rock desertification control areas, biodiversity conservation areas, and water conservation areas. In these ecology-related or agriculture-related areas, the development of modern industry is restricted or prohibited.

With such districts being remote or sometimes part of preservation areas, poverty alleviation can be hindered. There is little income and inefficient farming methods and the fact that people still rely on traditional agricultural systems means that many people in these areas are poverty stricken. This is exacerbated the phenomenon of rural hollowing and land abandonment due to population migration. This phenomena could threaten the food security of China.

7.2.2 Three typical mountainous GIAHS sites in China

1 Honghe Hani Rice Terraces Systems

The Honghe Hani Rice Terraces System (Figure 7.1) is located in the Honghe Hani and Yi Autonomous Prefecture, in the southeastern region of Yunnan Province, China. The heritage area is mainly spread along the southern slopes of the Honghe Ailao Mountain range and covers four counties: Honghe, Yuanyang, Jinping and Lvchun, covering an area of about 70 000 ha. People of many ethnic groups have built this spectacular agricultural masterpiece, but it is named directly after the Hani minority, who have lived on this remarkable landscape for more than 1 300 years. The local people have developed a complex system of channels to bring water from the forested mountaintops to the terraces. The local people worship the sun, moon, mountains, rivers, forests and other natural phenomena including fire. The inhabitants, integrated management of natural resources such as the forest, biodiversity, terrace landscapes, river, village or settlement sites and their traditional customs and diverse cultures which help to protect and conserve the environment make Hani a region where society and the environment seem to exist in harmony. The Hani Rice Terraces are a "forest-village-terrace-water-culture" compound system and in 2010, were designated as a GIAHS by FAO. In 2013, the UNESCO's World Heritage Committee announced

Table 7.2 Designated GIAHS in Mountainous Area

Countries	GIAHS sites	Year of designation
Chile	Chiloé agriculture	2005
China	Qingtian rice-fish culture system	2005
	Wannian traditional rice culture system	2010
	Honghe Hani rice terraces system	2010
	Congjiang Dong's rice-fish-duck system	2011
	Pu'er traditional tea agrosystem	2012
	Shaoxing Kuaijishan ancient Chinese Torreya	2013
	Fuzhou jasmine and tea culture system	2014
	Diebu Zhagana agriculture-forestry-animal husbandry composite system	2017
	Rice Terraces in Southern mountainous and hilly areas	2018
India	Saffron heritage of Kashmir	2011
	Koraput traditional agriculture	2012
Italy	Olive groves of the slopes between Assisi and Spoleto	2018
Japan	Noto's Satoyama and Satoumi	2011
	Sado's Satoyama in harmony with Japanese crested ibis	2011
	Managing Aso grasslands for sustainable agriculture	2013
	Traditional tea-grass integrated system in Shizuoka	2013
	Kunisaki peninsula Usa integrated forestry, agriculture and fisheries	2013
	Ayu of the Nagara river system	2015
	Minabe-Tanabe Ume system	2015
	Takachihogo-Shiibayama mountainous agriculture and forestry system	2015
	Nishi-Awa steep slope land agriculture system	2018
	Traditional wasabi cultivation in Shizuoka	2018
Morocco	Oases system in the Atlas Mountains	2011
Philippines	Ifugao rice terraces	2005
Portugal	Barroso agro-sylvo-pastoral system	2018
Korea	Traditional Hadong tea agrosystem in Hwagae-myeon	2017
	Geumsan traditional ginseng agricultural system	2018
Spain	Málaga raisin production system in Axarquía	2017
Tanzania	Shimbwe Juu Kihamba agroforestry heritage site	2008

that the Cultural Landscape of Honghe Hani Rice Terraces was to be placed on the prestigious World Heritage List.

The Hani Rice Terraces Landscape (Figure 7.1) provides multiple goods and services for local livelihoods and society and they contribute to meeting the food, fuel and other diversified needs of its inhabitants.

This landscape and contains multiple values as a development model in southern mountainous area of China in the fields of production, ecology, society and culture. After the terraces were designated a GIAHS site, the Hani Terraces Administration of Honghe Prefecture was established to take charge of the dynamic conservation and sustainable utilization systems and to offer regular monitoring and evaluation.

Figure 7.1 Honghe Hani Rice Terraces System in Yunnan Province

2 Congjiang Dong's rice-fish-duck system

Congjiang County is a mountainous area located in Qiandongnan Miao and Dong Autonomous Prefecture, China. The ethnic groups living there are Miao, Dong, Yao, Zhuang, and Shui among others. The Dong people, a branch of the Baiyue people, had long lived on the southeastern coast before migrating and settling in the border regions of Hunan, Guizhou and Guangxi, where they lived on a diet dominated by rice and fish. Rice paddies remain the main source of food for the Dong community. But as well as rice, more than 200 kinds of wild plants are widely used for food in areas where the Dong live. Over 100 kinds of wild herbs feature in the Dong diet including, fern, bamboo shoots, and types of edible fungus. In addition, aquatic animals such as snails, eels, and loaches and aquatic plants like taro, lotus root, water celery and plantain which live and grow in paddy fields, are also eaten. As there is little contamination by chemical fertilizers, pesticides and other pollution in the region, the glutinous rice grown in the paddies is seen as organic and is regarded as good for health.

The age-old rice-fish-duck system is a typical and traditional way of eco-friendly farming which is followed by the Dong, who are the only ethnic group that still uses this farming approach and the associated

technology. Rice is grown in the paddies according to soil fertility and water supply. But the rice-fish-duck system allows for the multipurpose utilization of the same plot, and so meeting communities' nutritional demands for adequate animal and vegetable protein. Compared with many monoculture rice fields, the rice-fish-duck system offers more nutrition value, a longer food chain and a more complex food web. This extended food chain means that the local food system is stable and offers more levels of nutrition. The Dong rice-fish-duck system (Figure 7.2) was designated as GIAHS in 2011.

Figure 7.2 Guizhou, home to the Dong's rice-fish-duck system

Figure 7.3 Shaoxing Kuaijishan ancient Chinese *Torreya* in Zhejiang Province

3 Shaoxing Kuaijishan ancient Chinese *Torreya*

Kuaijishan, which encompasses 59 villages spread out among 12 townships in the north of Zhejiang Province, is home to around 10 500 000 ancient Chinese *Torreya* trees (Figure 7.3). The Kuaijishan community has always grown a wide variety of crops that are central to their culture and are the foundation of the region's development. The locals produce many products including cherries, bamboo shoots, chestnuts, melon seeds, grapes, sweet potatoes and Yunwu mountain tea, but the Chinese *Torreya* trees have always been the main source of local income as the techniques used to grow and harvest the trees produces a food product (Chinese nutmeg) that is famous for its exquisite quality and taste. It is therefore the basis of local livelihoods and the region's economic security. The total *Torreya* planting area in the city of Shaoxing is currently 20 000 hectares, with 9 667 hectares in Zhuji, 7 467 in Shengzhou and 2 533 in Shaoxing County. The region's total *Torreya* production area is currently estimated at 5 667 hectares; among these, 720 000 trees are more than 100 years old, and thousands of them are more than 1 000 years old.

Overall, the Kuaijishan community not only possesses historical, artistic, scientific, ecological and economical value, is also a shining example of sustainable development that ensures the careful sustainable utilization of natural resources without diminishing their supply. Due to a well-estimated marketing mechanism developed over the past few years, the income of

Torreya farmers has gradually increased without negatively impacting their age-old traditions or the natural environment. The culture of the Kuaijishan community reflects a deep understanding of humankind's dependence on the need for a stable and well-conserved natural environment. The Kuaijishan Ancient Chinese *Torreya* was designated a GIAHS site in 2013.

7.3 GIAHS approaches to integrated mountain agricultural development

7.3.1 Promotion of characteristic products

Food production remains the core function of traditional agricultural systems. These food resources play an important role in protecting the livelihood security of local residents. GIAHS are not only concerned the traditional production of food crops, but also consider the other benefits of traditional production including how such systems contribute to the world's cultural heritage. The Honghe Hani Rice Terraces System is a good example of the sort of system where traditional food agriculture can be used to preserve culture while working towards poverty alleviation. There are 195 varieties of rice grown in the area, including 48 varieties of local rice. The local government in Hani pays great attention to the protection and utilization of

traditional food crops, the establishment of germplasm resources and the promotion of marketization of red rice and purple rice, to achieve the goal poverty alleviation.

Agricultural biodiversity plays an important role in the diversification of local diets in mountainous areas. For example, Congjing Dong's rice-fish-duck system, which was listed as GIAHS site in 2011, is rich in varieties of agricultural biological species and offers diverse food sources. More than 100 species of flora and fauna can be found in the rice field including carp, local-specific water ducks and Sansui ducks, but also wild aquatic animals such as scorpions, loach, scutella, shrimps, clams, crabs, loach, seven-star fish, as well as wild plants such as white peony, lotus roots, sage, and water celery. In addition to harvesting rice and raising fish and ducks, farmers also like to plant crops in areas adjacent to the rice fields such as soybeans, sweet potatoes, corn and various vegetables and fruits that can help to supplement local diets. The abundant agricultural biological resources provide a wide range of ingredients. The rice-fish-duck system not only helps to mitigate the problems of land shortage by allowing more food to be produced from the same land, it also gives residents the chance to make extra income by selling sideline products.

This promotion of extra local products is one of the most effective methods of bringing extra value to mountain agriculture. The designation and conservation of GIAHS helps producers to make full use of the advantages of branding. It also helps with consumer recognition of products, ensures higher prices for the same products and directly accelerates value-addition.

In Zhuji, the production and processing of Torreya is the traditional industry (Figure 7.4). Torreya nut production has a long history thanks to the vast forests, high output and top quality product. Zhuji was named "The Hometown of Torreya" in 1997 and in 1994, the first local brand of Torreya, was registered in Zhaojia Town. Before 2000 there were fewer than 10 local brands or processing companies functioning in the area. As of 2018, 50 processing companies have been registered. With the region now designated as a GIAHS site, there is a guarantee that the traditional planting area will be well-preserved and that the price of Torreya will rise. A hectare of Torreya trees can bring in CNY 150 000 RMB annually.

Local governments need to encourage companies to increase investment into scientific research in Torreya, to help develop other kinds of product. In recent years, not only have Torreya nuts been selling well, but so have related products such as Torreya essential oil,

Figure 7.4 The Fengqiao Torreya nuts



Torreya soap, Torreya wine and Torreya cookies. These have been promoted in national and international agricultural exhibitions, which has undoubtedly increased the visibility and enhanced the brand and sales of Kuaijishan Ancient Chinese Torreya.

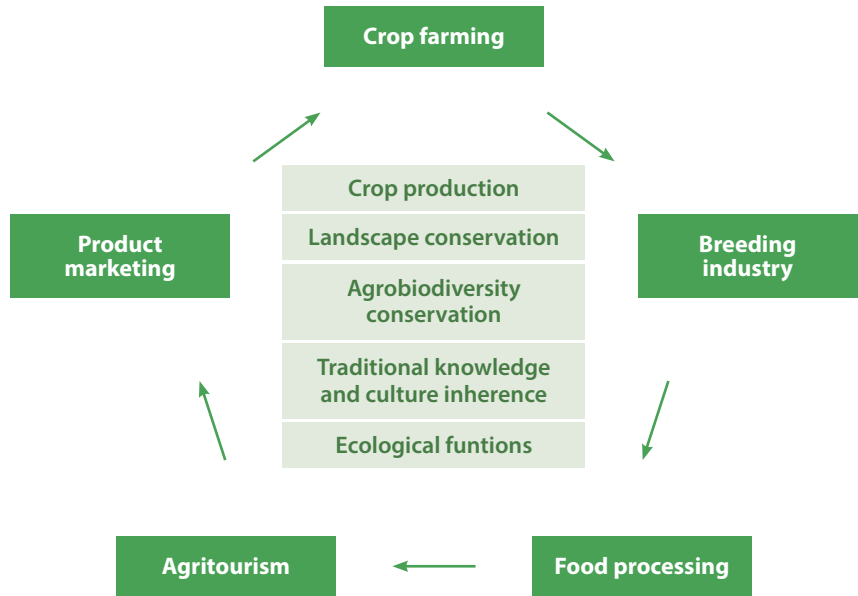
7.3.2 Prolongation of agricultural function

The increase in capacity of agriculture functions, and conservation of natural resources are two result of an area achieving GIAHS statue, as is the value added to local products. (Figure 7.5). But of equal importance is the protection provided to cultural inheritance and the ecological protection at GIAHS sites, which maximises the huge value of mountain agriculture.

In fact, GIAHS systems are not only rich in resources, but also have a distinct brand advantage. Studies show that the pollution-free environment of the GIAHS make them suitable organic production. This means that endemic crop varieties and indigenous animal varieties with the GIAHS brand have a higher market value than many modern and improved varieties and breeds. For example, red rice from the Hani Rice Terraces System is labelled with a national geographical indication and is also used as a raw material to manufacture distinctive ecological products. This organic agricultural certification, based on traditional environmentally friendly technology, increases farmers' income and encourages farming communities to preserve their traditional agricultural heritage.

And food production can help make tourism in GIAHS areas more attractive as people enjoy purchasing local food products in the place that they visit. There is also a "feel-good" factor when people buy foodstuffs and souvenirs which they know to be traditionally produced and made in a way that preserves local customs and biodiversity.

Figure 7.5 Multi-functional agriculture and related industries



Located in an ecologically vulnerable region, the rice-fish-duck system of the Dong people has developed in a way allows different species and crops to be farmed symbiotically while also providing water resource services such as food and drought prevention, climate regulation and biodiversity conservation.

Such ecosystem functions are fundamental to the development of mountain agriculture as they can safeguard the value chain of the heritage system.

The Congjiang County Government has regards GIAHS designation as fundamental to ecological and environmental preservation. What's more, the Important Ecological Function Zone helps to prevent and control agricultural pollution and ensure that there is a high quality natural environment where organic products (glutinous rice, pigs, fish etc.) can be raised. These nutritious and organic products are in high demand among consumers.

As well as eco-agricultural products, other goods and services benefit from GIAHS designation and these bring in more visitors and therefore more income. Cultural and eco-tours and handicraft sales for example, can be promoted to attract visitors. A good example of a cultural tourism attraction is the Dong Chorus (figure 7.6), traditional singing troupes from the Jiabang Terraces, who attract visitors with concerts of music. In the Biasha Village, the Musketeer group, impresses visitors with displays of marksmanship and traditional dress. Word has spread and the culture of both of these cultural groups is now becoming more known

internationally, bringing more tourism. It is the integration of culture and agriculture that gives the GIAHS such value and does so much to improve the livelihoods of local communities.

Figure 7.6 The Dong chorus singers



During the busiest farming times of the year, there is a lot of work for rural labourers to do. But depending on the crop, during other seasons, there may be less work to do, and so people are left unemployed or have to seek other forms of income. So the development of mountain agriculture systems has to take this into account, and ensure development of other related industries at the same time (Zhang *et al.*, 2018).

Multifunctional agriculture systems (Figure 7.5) can easily incorporate agrotourism and other leisure pursuits for visitors. Farms can offer accommodation, sightseeing tours, visits to local festivals and education in farming and nature studies (He and Min, 2013).

Traditional farming culture can easily support leisure agriculture as such farming systems are often located in landscapes of great beauty. Such landscapes are further preserved by GIAHS designation which encourages balanced ecosystems, affiant biodiversity, and organic farming practices. As a result, people see GIAHS regions as places to explore or relax in. Two surveys conducted in Japan show that cultural attractions are a prime motivation for tourists, as well as being a core GIAHS selection criteria.

In this regard, there have been many successful cases in GIAHS sites. The magnificent terrace landscapes and the colourful Yi festival have encouraged many people to visit the Honghe Hani Rice Terraces System. Between 2012 to 2017, tourism revenue in Honghe County, the core area of the GIAHS sites, increased from USD 597 million to USD 1.72 billion.

However, one of the main objectives of GIAHS is to develop the ability to offer tourism activities and boost local income in an appropriate, sustainable way that does not have any negative impact on the agricultural activities taking place there. The development of leisure agriculture must have a positive effect on heritage conservation, the reduction of poverty and livelihood security. The development of tourism can also benefit local communities in terms of infrastructure and improved communications (Fox and Cox, 1992).

The development of leisure agriculture can create opportunities for the poor and hungry to improve their livelihoods with better labour conditions. It can also promote productivity-enhancing investments e.g. in better infrastructure, information services, and logistics. Non-agricultural employment opportunities will grow alongside agricultural development. The new productivity-enhancing investments can increase the total capital used for sustainable agricultural production, increase the ratio of capital labour, and allow structural changes to proceed smoothly. Investment in industries other than agriculture will develop more employment opportunities, absorbing the surplus labour of the agricultural sector that is a result of mechanization, seasonality of crops and a range of other factors.

7.3.3 Preference of development policy

The designation and conservation of GIAHS sites is conducive to the recognition and activation of local governments to adopt laws, policies, documents to guarantee and accelerate the dynamic conservation and sustainable development of the GIAHS sites within their areas of responsibility.

Since 2000, governments at all levels in Yunnan Province and within the Honghe Hani and Yi Autonomous Prefecture have placed great importance on the conservation of the Hani Rice Terraces. To this end, in 2007, administration of World Heritage site in Honghe Hani and Yi Autonomous Prefecture was placed under the auspices of Honghe, Yuanyang, Jinping and Lichun counties, which were jointly responsible for planning, management and conservation. Soon afterwards, administration bureaus at the county level were established. The two-level management agencies follow the principle of “timely salvation and scientific conservation, rational use and strengthened management”, and are responsible for carrying out systematic and dedicated work looking after the five key elements of the heritage system: forest, village, terrace, water and culture. This involves building management institutions, improving laws and regulations, promoting industrial development and strengthening scientific research.

Between 2011 and 2014, the governments of Honghe Hani and the Yi Autonomous Prefecture published and implemented a series of laws, regulations and policy documents to accelerate the conservation of Hani Terraces. These regulations included “the Conservation and Management Approach of Hani Terraces” and, “the Overall Conservation and Management Planning of Hani Terraces” among others. The planning framework will be further enriched by formulating more detailed planning in the four counties. The administration of World Heritage in Honghe Hani and Yi Autonomous Prefecture have already released several documents to regulate the use of World Heritage logos for GIAHS and the China National Wetland Park, and have authorized 20 cooperatives or companies to use the logos on their products. This move gives recognition to eco-agricultural products already on the market such as red rice and duck eggs. The move also paves the way for the development of ecotourism in the Hani Terraces, improving incomes for local inhabitants and enhancing the value of the whole heritage system.

7.3.4 Participation of multi-stakeholders

The designation and conservation of GIAHS is a multiparty process. The participation of several interested stakeholders helps optimize value distribution and construction of value chains, to motivate all sides, to create new points of growth and finally, to promote the value-addition of the GIAHS sites. In the Hani Rice Terraces System, many villagers live in poverty due to poor natural and cultural conditions even though they possess an excellent ecological infrastructure and can make nutrient rich products.

The process of applying for GIAHS legacy offers villagers, local governors and entrepreneurs an opportunity to explore a new kind of cooperation. Many production cooperatives are established to develop “rice-fish-duck” compound production. They adopt the development model of “leading enterprise + professional cooperative + the production base of high quality rice + local government”, to ensure a win-win effect. In the past, farmers were often the most overlooked element of regional development, however in this cooperation model, they are motivated and have a great deal to gain. This makes the process of value adding even easier, as farmers see the benefits.

Increased cooperation between stakeholders at all levels of the development model and better use of local resources will help to promote conservation and value-addition of GIAHS sites.

7.4 Discussion

GIAHS regions have been maintained over centuries and the land, traditions and ways of working at passed from one generation to the next. This ensures a tradition of long-term dynamic adaption. The establishment of GIAHS is merely a continuation of this with the bonus of incorporating conservation and protection policies and assessment of ecosystem services as well as the development of ecotourism. GIAHS status also helps with the branding of local products to ensure better incomes (Liu *et al.*, 2013).

Another advantage of GIAHS is that it enables not only farmers to benefit, but also local governors, entrepreneurs who will take advantage of the many benefits of mountain agriculture in China which will help lift people from poverty and improve local economies.

Of course, resources are not the same in every region. Some areas have better infrastructure and communications, more advanced industry and greater integration of agriculture. But on the whole, GIAHS offers greater economic development through multifunctional agriculture, extended value chains, and a multi-party benefit sharing mechanism.

As most GIAHS sites are found in under-developed areas where there are traditional problems such as population outmigration owing to poverty. This results in rural hollowing, abandoned farmlands and the disappearance of traditional culture and farming technologies. GIAHS could reverse this by promoting integrated mountain agriculture development based on the GIAHS brand and making use of the many resources and advantages that agricultural heritage sites offer. This conservation strategy should preserve landscapes and communities by bringing people back to areas they’ve left, knowing they can make a living.

There are many ways that people living in heritage sites can participate effectively in tourism. Local families can offer their homes as accommodation and provide transportation for tourists. Family members find employment as cooks, tour guides etc. while local shop owners and manufacturers can to produce handicrafts or educate people about local customs and traditions.

Unlike the mountain agricultural development models in countries such as Japan, China has its own characteristics, such as a small per capita arable land area and a more dispersed living and farming space. Therefore, it will be necessary to explore more development models of mountain agriculture that are better suited for China's national conditions.

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8 Strengthening the governance of mountain agriculture, food security and nutrition: An analysis of survey on mountain agriculture in Asia

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8.1 Introduction

Mountain regions are home to a significant portion of the world's population however, living in such regions is a challenge. The environment can be harsh and rugged landscapes and limited connectivity means there is little access to social services. Such regions are also increasingly vulnerable to affects of climate change.

It is estimated that around 300 million people in developing and transition countries living in mountain areas are food insecure and that around half of them suffer from chronic hunger (Mountain Partnership, 2014). However, it is also recognized that mountain areas have great potential to overcome the challenges they face. Mountain areas are rich in water resources and biodiversity and can sustain crops that can be developed to improve food security and nutrition of the local population and meet requirements of other specific markets. The different agro-ecological conditions in mountain areas can also be conducive for growing a wide range of crops that can contribute to increasing agriculture productivity throughout the year.

Despite this great potential, most mountain areas remain untapped and undeveloped. Mountain agriculture faces peculiar challenges ranging from biophysical-technical, socio-economic, policy and institutional perspectives. To better understand the multidimensional constraints for mountain agriculture in selected Asian countries: i.e. Bangladesh, Bhutan, Cambodia, India, Lao PDR, Myanmar, Nepal, Pakistan and Viet Nam, the FAO has surveyed experts in mountain agriculture who were nominated by nations above. The survey covered topics related to issues and the constraints of Mountain Agriculture Development in biophysical-technical,

socio-economic, policy and institutional dimensions. The experts were asked to identify challenges facing mountain areas in the countries they represented. They were also asked to consider the importance of such challenges and to suggest working solutions and offer examples of successful solutions to the problems that mountain regions face.

Based on the results of the survey, a policy framework has been suggested to rationalize strategies and priorities for sustainable mountain agriculture development using information derived from the analysis of the survey from national and international experts on this subject. Challenges related to mountain agriculture are multidimensional and require coordinated and targeted initiatives that can contribute to the overall goal of achieving sustainable mountain agriculture development. In this framework, it is suggested that there needs to be a focus in developing mountain specialty products to serve as a driver for mountain agriculture development. The framework prescribes a specific strategy for sustainable mountain agriculture development and it also suggests a set of guiding principles for its adoption. The principles suggested to serve as an overarching guide while developing initiatives based on the framework.

8.2 About the survey on mountain agriculture in Asia

Objective

The objective of the survey was to gather information from national and international experts on the status and multi-dimensional challenges facing sustainable

mountain agriculture development, to offer suggested solutions to these challenges, and provide successful examples of proposed solutions.

Country coverage

The survey was undertaken by experts from countries including Bangladesh, Bhutan, Cambodia, India, Lao PDR, Myanmar, Nepal, Pakistan, Thailand and Viet Nam.

Methodology

The survey focused on constraints relating to biophysical-technical, socio-economic, institutional and policy. Pre-identified potential constraints were listed in the survey forms and experts were asked whether these constraints are present in their countries and to then assess their level of importance (Annex I: Survey questionnaire). The identified issues and constraints were prioritized based on scores by respondents from lowest priority (1) to highest priority (5) and the results averaged to determine which issues/constraints were the highest priority to address. While the survey population was limited, it reflects each country's experience relating to the common challenges for mountain agriculture.

Suggested solutions were open-ended responses and were often unique for each respondent as they were based on local context and experience. In cases where similar responses were given, these were grouped together in the presentation of results. Collected responses for suggested solutions were analyzed by finding links and similarities according to themes, and these were used in developing the strategic framework.

8.3 Survey analysis and results

8.3.1 Main constraints for mountain agriculture in Asia

To better understand the challenges for mountain agriculture in Asian countries, the FAO organized policy dialogues and country surveys on mountain agriculture for the nine selected countries in Asia. While each country in the survey faces its own particular challenges, in terms of mountain agriculture, there are some issues each has in common. These include:

- 1 Low agricultural productivity due to inadequate quality inputs including seeds, tools, fertilizer, labour, and access to credit. There is also little capacity for research and development to provide improved technologies in mountain agriculture.

- 2 Poor agriculture infrastructure, especially water and irrigation systems and transportation facilities which pose significant challenges to achieve sustainable mountain agriculture development to enhance food security and nutrition.
- 3 Limited cultivatable land in term of size, use and tenure. There are also issues of soil infertility and erosion, which could affect development of mountain agriculture.
- 4 Limited improved technologies for farming practices, sustainable farming systems and post-harvest handling and management.
- 5 Lack of marketing outlets and facilities, including underdeveloped market information systems and poor transportation links, makes it hard to access markets and compete on price.
- 6 Variable climate and natural hazards, natural resource degradation and deforestation have a negative impact on mountain agriculture development and consequently food security and nutrition.
- 7 Limited policy support and implementation in place that targets sustainable mountain agriculture development.

Results

1 Biophysical-technical constraints:

A number of constraints were considered in this category: (a) sloping land; (b) seasonal hazards; (c) climate change; (d) limited inputs, e.g. lack of improved seeds, fertilizer and pesticides; (e) poor infrastructure; (f) low productivity; (g) lack of information on important major crop commodity groups with high potential, as well as adapted livestock types; (h) low cropping intensity preventing effective implementation of integrated farming systems; (i) lack of suitable and improved farming techniques/limited cultivated land with low environmental impact; (j) lack of research and development; (k) lack of extension services to disseminate technology and improve farmers' capacity; (l) lack of balance between agriculture and conservation of biodiversity of the mountain ecosystem.

The responses to biophysical-technical constraints identified "seasonal hazards" and "poor infrastructure" as most important challenges. Poor infrastructure is related to gaining physical access to markets, while seasonal hazards can affect productivity in mountain areas.

2 Socio-economic constraints

A number of constraints were considered in this category: (a) lack of defined land tenure rights; (b) isolation and lack of market access; (c) an aging society and lack of human labour/urban migration; (d) lack of market information/poor access to telecommunications; (e) lack of marketing power and knowledge/poor education facilities; (f) lack of reliable transportation networks; (g) lack of organizing capacity/organized farmer associations; (h) lack of financial resources; (i) lack of investment, etc.

The responses to socio-economic constraints identified a “lack of market information and poor access to telecommunications” as being the important followed by “isolation and lack of market access/transport networks”. These constraints are related to physical access to markets and having information that is useful for accessing markets. The issue seen as of the lowest concern was “lack of financial resources”, indicating that communities may have sufficient financial resources available or access to alternative sources such as microcredit.

3 Policy constraints

A number of constraints were considered in this category: (a) lack of data/information on level of poverty, food security and nutrition of mountain populations; (b) lack of targeted mountain-specific strategies or policies at national level; (c) lack of subsidies/incentives schemes for mountain agriculture; (d) lack of social protection schemes for mountain people; (e) lack of attention and support by policymakers to mountain regions; (f) lack of empowerment of mountain communities in decision-making processes; (g) lack of effective international cooperation; (h) lack of non-market valuation methods and institutions; (i) lack of promotion for farmers associations and federation for marketing, resource use and engagement in policy and regulatory issues.

The responses to socio-economic constraints identified the “lack of information and policy support on mountain speciality products” as most important, and the “lack of effective international cooperation” as least important constraints.

4 Institutional constraints

A number of constraints were considered in this category: (a) lack of governance support; (b) lack of promotional activities for mountain agriculture

products; (c) lack of investment; (d) lack of organized institutional support to connect value chain components – namely production, processing, marketing and consumption for mountain regions; (e) lack of targeted poverty reduction in mountain areas; (f) lack of knowledge sharing on how to strengthen Future Smart Food (FSF) crops in mountain areas both nationally and regionally.

The responses to institutional constraints identified “lack of organized institutional support to connect value chain components namely production, processing, marketing and consumption for mountain regions” as most important issue that was given greatest weight or priority.

In short, the survey emphasized that to address multi-dimensional constraints on mountain agriculture development, the most important issues were related to mountain products and market development, which contribute directly to poverty alleviation and addressing hunger and malnutrition. Product and market development should be considered the drivers for sustainable mountain agriculture development and the focus of development interventions. Other identified issues and constraints are linked to product and market development.

8.3.2 Suggested solutions to address multidimensional constraints facing sustainable mountain agriculture development

The previous section demonstrated that mountain agriculture faces multidimensional challenges including biophysical-technical, socio-economic, policy and institutional dimensions. In each dimension, several issues were identified with a high degree of importance. How to address these major multi-dimensional challenges for mountain agriculture development? In this section, the focus would be on suggested solutions to address multi-dimensional constraints that have the highest weights or which are considered as being most important. Solutions suggested by experts to address four-dimensional constraints are also enumerated along with their given examples, which are detailed in Annexes 2 to 5.

Results

Suggested solutions to address biophysical-technical constraints

For biophysical-technical constraints, addressing “seasonal hazards” and “poor infrastructure” were the identified as high priority. Suggested solutions to address seasonal hazards can be grouped according to improving awareness and early warning on hazards, improving agriculture production technology to adapt to hazards, providing crop insurance to cope with hazards, and developing early warning systems and disaster management plans to anticipate these hazards. It was suggested that knowledge sharing systems are strengthened and that climate change adaptation strategies should be promoted. To promote further adaptation, recommendations were made to enhance diversification and adopt proper agricultural production systems and improved technology packages and as well as climate smart agriculture farming to increase productivity and production. To be ready to cope with hazards, the implementation of early warning systems and preparedness through disaster management and contingency planning was also recommended.

Suggestions for addressing poor infrastructure included developing infrastructure transportation networks for mountain areas to improve connectivity (quality roads, airports, bridges etc.), construct storage houses, build irrigation facilities, and make climate-resilient infrastructure. The provision of public services on transport/vehicle for mountains to facilitate flow of people, goods and services through infrastructure networks was also recommended as a solution.

Suggested solutions to address socio-economic constraints

The identified priorities of socio-economic constraints were “lack of market information and poor access to telecommunications” and “isolation and lack of market access/transport networks”. Other constraints include “lack of defined land tenure rights” and “aging society and lack of manpower/urban migration”. The suggested solutions for the priority constraints or lack of market information includes developing up-to-date market information systems and this may be supported by using ICT and extension services. To help solve the problems of isolation and lack of market access, the suggestions were to build infrastructure including quality roads, ports and airports, and market outlets with potential new market opportunities. Building capacity on management market infrastructure and facilities was also suggested.

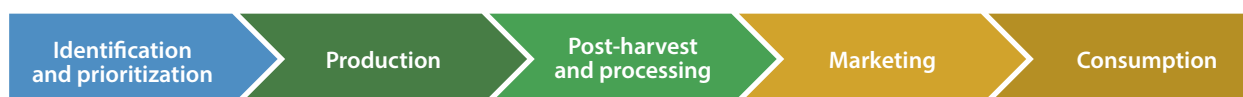
For the constraints of lack of defined land tenure, suggestions were to establish land tenure and use rights, recognize customary and indigenous rights, and to institutionalize contract farming.

Examples given to address lack of market information were improved telecommunication facilities throughout the country with access at affordable rates in India. In Myanmar, Build Operate Transfer (BOT) schemes were implemented for road development to improve infrastructure in Shan State. Special Economic Zones (SEZ) for agricultural commodities were developed in India. For land tenure, Bhutan has brought in a land act that provides equal access and individual rights to land ownership and periodic revisions to update land reforms by the State.

Suggested solutions to address policy constraints

In terms of policy, the priority constraint is the “lack of information on mountain speciality products”, and other constraints are “lack of targeted policy support for promotion of mountain speciality products and “lack of empowerment of mountain communities in the decision-making process”. The suggested solutions for priority constraints are to identify projects for the production of mountain speciality products which can be undertaken by reviewing existing data on mountain agriculture, to coordinate the dissemination of information about the mountain speciality products, and organize promotional activities at local, national and international levels.

Further suggestions include that promotion of mountain products to be supported by a national strategy or policy for the promotion of mountain speciality agriculture products, to improve the capacity of smallholder farmers to grow and produce added-value mountain speciality products, and to then find ways to link them with markets. Smallholder farmers need to be empowered through their involvement in development of initiatives and decision-making processes and should be encouraged to enhance their capabilities through training for sustainable agricultural development. Research and development activities to be developed to ensure a balance between a top-down and bottom-up approach in generating and transferring improved technologies that would enhance farmers’ productivity in mountain agriculture.

Figure 8.1 Development stages of food systems and value chain for mountain speciality products

In terms of promotion and marketing of mountain speciality products, Myanmar offers example by using Myanmar agribusiness journals and TV channels. The One Village One Product (OVOP) approach and Globally Important Agricultural Heritage Systems (GIAHS) were suggested strategies that could be emulated to promote mountain speciality products.

Suggested solutions to address institutional constraints

The identified priority institutional constraints were the lack of organized institutional support to connect the components of commodity value chain – namely production, processing, marketing and consumption for mountain speciality products. Other constraints identified were a “lack of investment for institutional support” and “lack of promotional activities for mountain agriculture products.” Suggested solutions for the priority constraint are related to developing a comprehensive and holistic approach for the development of mountain speciality agriculture products. These solutions range from building an information system about such products and using these to improve awareness and for promotional activities. There also is a need to improve processing and packaging, and enhance the distribution and marketing of the mountain speciality products.

Suggestions to tackle other constraints included establishing a dedicated office in the Ministry of Agriculture or Trade and Commerce to implement coordination activities. These activities may also be implemented in coordination with non-government organizations (NGOs).

For promotional activities, it was suggested that this will be supported by organizing regular fairs and the collection of scientific information and using these to show the benefits of mountain speciality products supported by certification, and to develop better cooperation and ties with international organizations. A good example of this is the Government of Thailand's longstanding commitment to regularly promoting local mountain products in national and international agriculture trade fairs.

Summary of major suggested solutions

Constraints that were given greater weight and priority by respondents were those relating to the development of mountain speciality products and to improving

opportunities to link with markets. This highlights the need to improve incomes and livelihoods of smallholder farmers living in mountain areas. Based on the suggested solutions, developing markets for mountain speciality products may be considered the main strategy or “driver” for strengthening sustainable mountain agriculture development. Developing mountain speciality products may (1) utilize the comparative advantages on production based on availability of natural resources and indigenous skills of smallholder farmers, (2) uniqueness of product based on location of production and mountain agro-ecological niches, and (3) increase agriculture productivity without compromising sustainability of production. Developing mountain agriculture products may be used to promote sustainable livelihoods in mountain areas (Joshi, 2015) and results of the survey are in line with this major benefit.

8.4 Rationalizing strategies for mountain agriculture development

8.4.1 Priorities for mountain agriculture development

While multidimensional constraints have been identified and various solutions suggested, it is important to rationalize priorities and to address physical-technical, socio-economic, policy and institutional issues from a food system and value chain approach in a holistic manner. This means taking into account contrasting situations at different stages of the food system for sustainable mountain agriculture development that benefits both mountain and lowland populations. What are the priorities that can turn challenges into opportunities that mountain agriculture offers?

Mountain agriculture is composed mostly of family farming (Dach *et al.*, 2013) and developing mountain specialty products (e.g. FSF products with mountain specialty) which are vital when it comes to improving livelihoods through increased incomes and improved food security and nutrition. From a food system perspective, to harness the opportunities that mountain agriculture offers for Zero Hunger and poverty reduction, priority should be given to strengthening production, post-harvest handling and processing, the marketing

and consumption of mountain speciality products (Figure 8.1). Identifying mountain speciality products should follow certain criteria to identify NUS as potentially FSF to ensure sustainability (FAO, 2018). By doing so, mountain communities could produce sufficient, nutritious and safe food for themselves, and gain economic benefit from surpluses in agricultural products and services. This needs to be well organized to ensure environmental sustainability, conservation and the sustainable use of natural resources. Biodiversity should not be overexploited in the pursuit of economic development. Overall, emphasis should be given to (1) building capacity for the development of mountain speciality products at each development stage of the food system and value chain, i.e. prioritization, production, post-harvest handling and processing, marketing and consumption, and (2) coordination and building connectivity between all stages of the food system and value chain to minimize transaction costs and to produce high quality added-value mountain products.

Entry points for the mountain speciality products prioritization, production, processing, market development and consumption

In terms of the developmental stages in the food system and value chain, the main entry points include: (1) scope and prioritize mountain speciality products based on mountain niches and their agro-climatic advantage. It is advised to identify and prioritize mountain products against the four-dimensional criteria of FSF, i.e. nutrition value, climate resilience, economic viability and local availability or adaptability (FAO, 2018). The prioritization process should also be based on science, taking into account the market value and potential of the mountain speciality products; (2) organize mountain producers and build their capacity to produce more mountain speciality products to meet demand, including food commodities and services for urban markets and the inflow of tourism; (3) promote diversified, integrated and sustainable farming systems to enhance the productivity and profitability of agricultural production; (4) establish post-harvest, storage and agroprocessing centres in mountain areas or close to mountains by providing financial assistance and facilitation to mobilize investment of the private sector; (5) provide regulatory support such as standards, certification, branding, labelling and the implementation on sustainable management regimes for mountain speciality products (OVOP, Mountain Partnership Product, etc.), and build capacity to enable the development of special mountain speciality products to meet quality requirements of

manufacturers, processors, and high-end markets; (6) organize promotional activities for mountain speciality products, highlighting their nutritional and health benefits; (7) promote consumption of mountain speciality products through school feeding programmes, chef associations and organized food supplies in hospitals, etc. Points (1–3) are related to production, points (4) and (5) are related to post-harvest handling and agro-processing, point (6) is related to marketing, and point (7) is related to consumption.

Prerequisites to fill the gaps on connectivity

Promoting mountain agriculture development through the identification of mountain speciality products along with their production, post-harvest handling, and market development requires prerequisites and initiatives to realize the many benefits and huge potential. Yet, despite this potential, the performance of the mountain agriculture sector is constrained as mountain farmers are often unable to reach high-value markets due to remoteness, the cost of establishing agribusiness, and a lack of market information. While agribusiness is a crucial lever for rural income and livelihood improvement in mountains, there is a lack of necessary infrastructure, logistics support and information connectivity to ensure that mountain farmers' harvests reach the markets in a timely manner. Coordination and connectivity between various developmental stages of food systems and value chain are crucial. An established link facilitates the flow of information and requirements in both directions: it allows high quality mountain agriculture products to reach urban and lowland areas and for tourists to reach mountain areas. It also facilitates the flow of technology developed in urban and lowland areas, and information and services that could be used or adapted to mountain areas.

But how best to build connectivity and reduce transaction costs between mountain areas and markets mostly in urban and lowland areas? Investments are required in two areas are critical: (1) development of infrastructure and (2) establishment of market information systems. In terms of developing infrastructure for mountains, effort should be made to build transportation networks, infrastructure for water and energy as well as, roads, bridges, airports, electricity, irrigation systems, communications and market facilities. These are important to connect people, goods and services between mountain areas and to urban and lowland areas. An improved transportation infrastructure will not only significantly reduce transaction costs for mountain products from the mountains to the end

markets, but also generate a flow of tourists from urban and lowland areas to mountain areas, creating demand for fresh local mountain products and improving job opportunities. Improved communication infrastructure, including ICT facilities, will enable mountain smallholders to access market information and extension services. The provision and development of infrastructure facilities for mountains is mostly the role of the government as they benefit nations as a whole and are therefore a public good. Government authorities should formulate sectoral policies in transportation, irrigation, electricity, communication and market facilities that acknowledge the need for mountain-specific approaches and technologies. Governments could use revenues from mountain tourism (entrance fees, trekking permits, tax etc.) and payment for environmental services to establish or improve infrastructure facilities in mountain areas. Governments should also encourage the private sector to participate in building infrastructure through PPP models, such as BOT schemes, and provide financial assistance to mobilize investments.

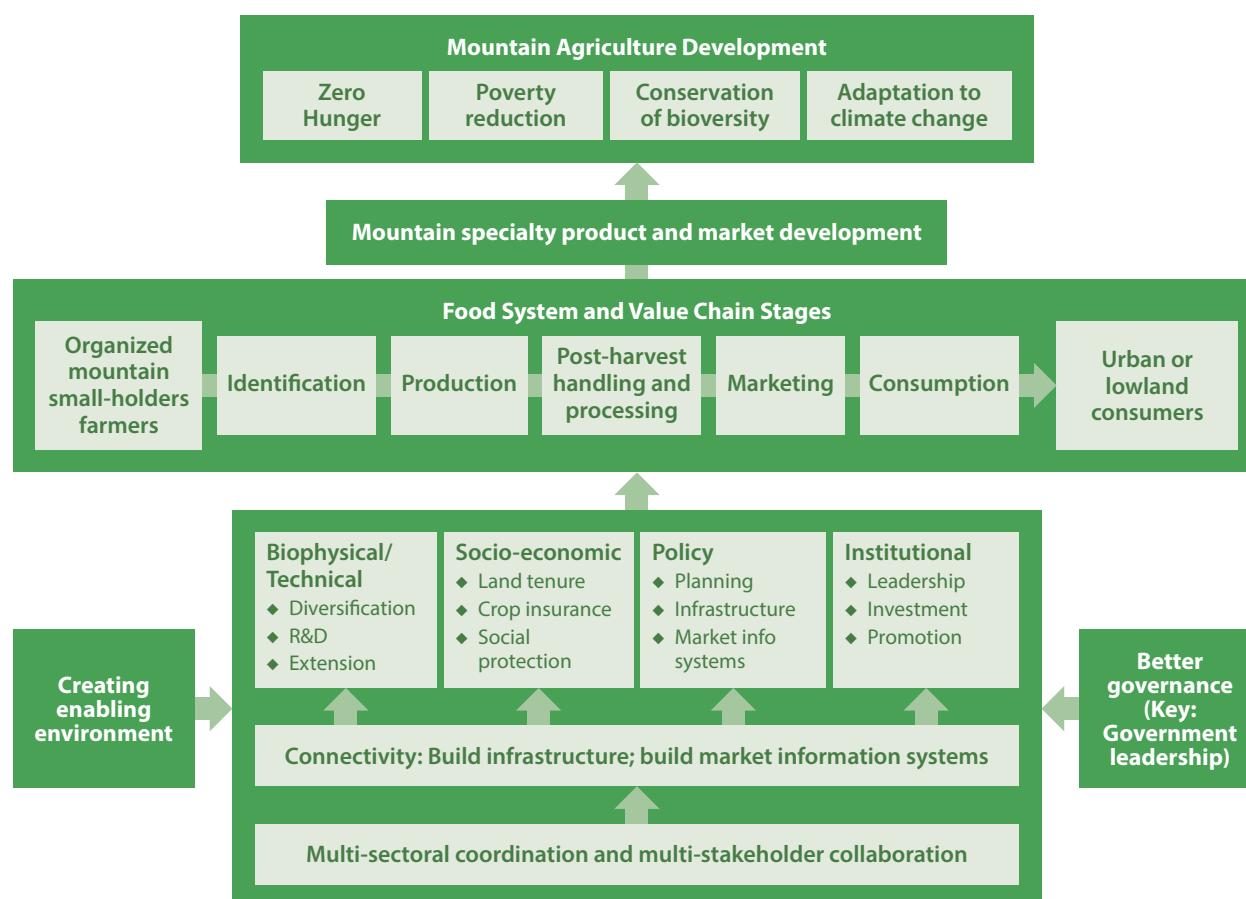
It is important to establish and develop market information systems for mountain areas to ensure that market information is available and accessible to the public including farmers and all stakeholders involved in food systems and value chains of various commodities. Establishing such market information systems is crucial since it will be the basis for (1) identifying markets products and services that can be offered by and to mountain communities; (2) providing quantity and quality requirements of various markets; (3) determining the volume and seasonality of products demand by various markets, and (4) providing market prices for products and services. These are important for determining the capabilities that need to be improved among mountain communities including technology that needs to be developed and provided, as well as the design of extension services, the structure of value chains, and governance systems. The collection and dissemination of market data and information can be performed by the government through an agribusiness and marketing assistance centre as market information may be considered as a public good (Shepherd, 1993). However, the private sector can also provide this information, particularly to those closer to consumers such as retailers. Value chain actors at the downstream end often know what consumers need and this information can be shared with farmers and producers in mountain areas to help them to target their production and products accordingly.

8.4.2 Policy framework for mountain agriculture development

Creating an enabling environment conducive to mountain agriculture development is essential. A policy framework for mountain agriculture development based on a food systems approach is recommended based on deliberations of the Consultation, Country Reports and the survey results. With the objective of tackling the challenges of hunger and malnutrition, poverty, the sustainable use of biodiversity and adaptation to climate change, through improved mountain agriculture could be achieved if there is a focus on promoting the identification or prioritization of mountain speciality products along with their, production, processing, market development and consumption, among others. The policy framework for mountain agriculture development offers suggestions for priorities on initiatives set for the sustainable development of mountain agriculture. However, it also recognizes that the situation in each country and locality varies and that the local context has to be considered (Figure 8.2).

Product and market development refer to the provision of products and services from mountain areas that can not only meet the own consumption needs of local communities but also wider market demand that can generate income for communities in mountain areas. This will involve value chain development for mountain speciality products that builds on sustainable food and agriculture production, post-harvest handling and processing, marketing and consumption within the food systems. The capabilities of mountain communities to meet the requirements for markets need to be enhanced through government leadership, with greater involvement by the local government unit. This will require provision of agriculture research and extension services, improved farming practices and better community organization. Social protection, land tenure and property rights are also vital parts of the enabling environment. Agritourism can also be promoted to increase awareness about the huge importance and uniqueness of biodiversity and the conservation of traditional the culture of mountain populations. Income generated by agritourism will contribute to improving livelihoods and consequently contribute to poverty alleviation and address hunger and malnutrition.

The development of high quality mountain products and markets need to be supported through coordination and by establishing connectivity among the stages or phases of the food systems and value chain. Policies and governance structures play a key role in facilitating this flow from one phase to another.

Figure 8.2 Policy framework for sustainable mountain agriculture development

The key to establishing this connectivity is improved coordination and governance across food system stages, including strategic planning and the development of integrated poverty reduction schemes, building infrastructure facilities for mountains, the development of national agriculture research and extension systems, the establishment of marketing information systems, and by forming industry and trade associations in mountain areas. The establishment of coordination and connectivity among the phases of the value chains which can provide information on market information for all stakeholders involved in the chain will contribute to high quality products and improved efficiencies.

The increasing demand from urban and lowland markets is a driving force behind initiatives to increase production of targeted commodities in mountain areas. Where there is market potential, the government can join the market forces by providing incentives to allow farmers to meet this demand for high quality products. For instance, in Ladakh, Northern India, the increased preference for pulse consumption led to the introduction of lentils into existing cropping patterns. This step was fostered by subsidies for lentil seeds established by the Agriculture Department. The key actors are the government and non-governmental

organizations who have the goal of increasing agricultural production in the region. They influence farmers' strategies and enhance changes in land-use systems. Government subsidies for high quality seeds, fertilizers and machines have fostered the implementation of new inputs and improved technologies (Dame and Nüsser, 2011). Contract farming is another means to secure demand for mountain products. Through contract farming, farmers can increase on-farm income and diversify livelihood strategies. In a local context, where farmers lack alternatives for income generation from agricultural production, the benefits provided by contract farming with guaranteed purchase without transportation costs improves their market access and helps to generate on-farm income.

Market demand has to be guided in a way that will encourage sustainable production and promote conservation and sustainable use of natural resources including indigenous biodiversity. This is because the technology and farm management practices that can increase productivity may be detrimental to the environment. This could entail overexploitation of natural resources and the excessive use of chemical inputs. In this case, it is important to enhance awareness

in urban and lowland populations about the importance of mountain speciality products that are nutritious, climate-resilient and sustainably cultivated or produced. Awareness of such products needs to be supported by certification schemes that can provide assurance to consumers that products are nutritious, climate-resilient and sustainably cultivated. Smallholder farmers in mountain areas should be provided with premium prices as incentives to produce such products in mountain areas. food commodities and agriculture products in a sustainable manner.

8.4.3 Guiding principles for mountain agriculture development initiatives

Building on policy frameworks for mountain agriculture development, the following are a few guiding principles suggested for developing mountain agriculture initiatives. It is suggested that these guiding principles be followed when developing localized strategies for sustainable mountain agriculture development.

- 1 **Using a holistic and food systems approach:** A system view is key when considering issues that are interlinked and solutions are needed to address the constraints facing all the phases or stages of the food system and value chain, namely production, post-harvest handling, marketing and consumption.
- 2 **Tailor-made to the local context:** It is essential to develop policies and targeted programmes that are tailor-made and needs-based. The programme design has to be appropriate for the local context to be effective.
- 3 **The role of government (especially local government):** It is important to highlight the role of government, especially local governments in local policy development and implementation, which is closest to the constituents and should take the lead in identifying demands for mountain speciality products based on marketing information systems. There needs to be a drive to organize and mobilize resources to tap into opportunities and generate outcomes conducive to support agriculture production in local area.
- 4 **Strategic planning:** It is important to identify targeted initiatives and actions that can address specific issues related to sustainable mountain agriculture development. This planning process, which should be initiated by local government, needs to be a development-oriented, science-based, and include participatory process that involves all stakeholders.
- 5 **Evidence-based for decision making and outreach:** Gathering data and information to provide evidence-based decision making is important, including analysing the status of hunger and malnutrition in mountain areas and identifying mountain speciality products with multidimensional benefits based on scientific-based evidence.
- 6 **Multisectoral coordination and multistakeholder participation especially from local communities and the private sector:** As mountain product and market development involves various stakeholders, it is essential to coordinate with the relevant sectors. Organized communities in mountain areas should be empowered by being actively involved in decision making. The private sector can be involved in the development of infrastructure facilities and marketing of mountain products.
- 7 **Enhancing coordination and connectivity links between mountains, markets and urban communities.** Mountain agriculture development cannot occur if mountain areas are not linked to urban lowland communities that serve as markets and sources of facilities and services. It is essential that links are established to facilitate the flow of goods, services and information through investment in infrastructure facilities, telecommunications and policies.
- 8 **Using Information and Communications Technology (ICT) as tools for collecting and disseminating information.** Information needs to be accessible to the greatest number of the mountain population in a timely manner and this may be achieved through developments in ICT system.

8.5 Conclusion

How to turn challenges into opportunities in mountain areas in the pursuit of Zero Hunger in Asia? This will require multidimensional interventions that are rationalized and coordinated through a “driver” strategy to address challenges in mountain areas. From a food system and value chain perspective, the priority should be given to focus on mountain speciality products (e.g. Future Smart Food with mountain speciality) with respect to identification, production, post-harvest handling, marketing and consumption. This would explore effectively the potential of mountain agriculture to contribute to Zero Hunger Initiative and poverty reduction. More specifically, the entry point for mountain product value chain development includes: 1) scope and prioritize mountain speciality products, based on the

four-dimensional criteria of Future Smart Food; 2) increase production of mountain speciality products by organizing mountain farmers, transferring improved technologies and building their capacity to produce more mountain speciality products to meet demand, 3) promote diversified, integrated and sustainable farming systems that enhance productivity and profitability (e.g. GIAHS); 4) establish post-harvest handling, storage and agroprocessing centres in mountain areas or close to mountains; 5) provide regulatory support such as standards, certification, branding, labelling and its implementation for high quality mountain speciality products (e.g. OVOP, Mountain Partnership Product, etc); 6) organize promotional activities for mountain speciality products, highlighting their nutritional and health benefits; and (7) promote consumption of mountain speciality products through school feeding programmes, chefs' associations and organized food supplies and fairs. While strengthening each development stage of the mountain speciality product value chain, building coordination and connectivity among these stages will be crucial for high quality

products to come to the fore. Investments in building infrastructure facilities and market information systems are critical to reduce transaction costs between mountains and markets. In short, identifying/prioritizing mountain speciality products is a starting point, but emphasis should be given to each stage of the food system and value chain to build strong connectivity between the stages and to bridge gaps between mountains and markets.

To create an enabling environment and so turn challenges into opportunities in mountain areas, a policy framework should be established and developed for mountain agriculture development based on a food systems and a value chain approach with guiding principles. It is the government's responsibility to create an enabling environment conducive to mountain agriculture development. Governments' support, especially local governments, are essential for turning these challenges into opportunities, by organizing and mobilizing resources to tap into opportunities and to generate outcomes conducive to local development in mountain areas.

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Annex 1 Questionnaire on main challenges, constraints and possible solutions for sustainable mountain agriculture development

	Main challenges and constraints (in your country/view to develop sustainable mountain agriculture?)			Possible solutions/tools/interventions (in your country/view to develop sustainable mountain agriculture?)	
	Issues	Yes/No (multiple choices)	Please give weight to how serious/challenging are these constraints from 1-5 (least – strongest)	Possible solutions, tools and interventions	Please indicate and elaborate if there is successful case in your country/to your knowledge
Policy	1 Lack of data/ information on level of poverty, food security and nutrition of mountainous people				
	2 Lack of information on what are speciality/niche mountain products				
	3 lack of targeted mountain-specific strategies or policy at national level				
	4 Lack of subsidies/ incentives schemes for mountain agriculture				
	5 Lack of social protection schemes for mountain people				
	6 Lack of attention by policy-makers on mountain regions				
	7 Lack of empowerment of mountain communities in decision-making processes				
	8 Lack of effective international cooperation				
	9 Others (.....)				
Socio-economic	10 Lack of defined land tenure rights				
	11 Isolation and lack of market access/ transport networks				
	12 Aging society and lack of manpower/ urban migration				
	13 Lack of market info/ poor access to telecommunications				

Questionnaire on main challenges, constraints and possible solutions for sustainable mountain agriculture development (*continued*)

	Main challenges and constraints (in your country/view to develop sustainable mountain agriculture?)			Possible solutions/tools/interventions (in your country/view to develop sustainable mountain agriculture?)	
	Issues	Yes/No (multiple choices)	Please give weight to how serious/challenging are these constraints from 1-5 (least – strongest)	Possible solutions, tools and interventions	Please indicate and elaborate if there is successful case in your country/to your knowledge
Socio-economic	14 Lack of marketing power and knowledge/poor education facilities				
	15 Lack of transportation				
	16 Lack of organizing capacity/organized farmers associations				
	17 Lack of financial resources				
	18 Lack of investment				
	19 Others (.....)				
Physical-Technical	20 Sloping land				
	21 Seasonal hazards				
	22 Climate change-whether it is affecting mountain agriculture in recent years and if so what extent (e.g. landslides, heavy rainfall etc.).				
	23 Limited inputs, e.g. lack of seeds, fertilizers				
	24 Poor infrastructure				
	25 Low productivity				
	26 Lack of information on important major crop commodity groups with high potential (field crops, fruit trees and pasture/ rangelands); as well as livestock types (e.g. sheep, goats and cattle) in the mountain agriculture production systems				
	27 Low cropping intensity preventing effective implementation of IFS				

Questionnaire on main challenges, constraints and possible solutions for sustainable mountain agriculture development *(continued)*

Main challenges and constraints (in your country/view to develop sustainable mountain agriculture?)				Possible solutions/tools/interventions (in your country/view to develop sustainable mountain agriculture?)	
	Issues	Yes/No (multiple choices)	Please give weight to how serious/challenging are these constraints from 1-5 (least – strongest)	Possible solutions, tools and interventions	Please indicate and elaborate if there is successful case in your country/to your knowledge
Physical-Technical	28 Lack of suitable farming techniques/ lack of cultivation or land use with low environmental impact				
	29 Lack of research and development				
	30 Lack of extension services to disseminate technology and improve capacity				
	31 Balance between agriculture and conservation of biodiversity in mountain ecosystem				
	32 Others (.....)				
Institutional	33 Lack of governance support				
	34 Lack of promotional activities for mountain agriculture products				
	35 Lack of investment				
	36 Lack of organized institutional support to connect production, processing, marketing and consumption for mountain regions				
	37 Lack of targeted poverty reduction on mountain				
	38 Lack of knowledge sharing on how to strengthen FSN in mountain areas nationally/regionally				
	39 Others (.....)				

Annex 2 Suggested solutions to address multi-dimensional challenges on mountain agriculture (1): Biophysical-technical constraints

Main constraints	Suggested solutions	Examples
Seasonal hazards*	(i) Enhance diversification and proper agricultural production systems combined with productivity-enhancing technology packages, (ii) provide crop insurance, (iii) adopt climate smart agriculture, (iv) strengthen knowledge sharing and promote climate change adaptation strategies, (v) increase public awareness on climate change, and (vi) implement early warning systems and preparedness through disaster management and contingency planning.	Myanmar: crop insurance system and special support programme for disasters
Poor infrastructure*	(i) Prioritize infrastructure transportation facilities for mountain areas to improve connectivity (quality road, airports, ports), (ii) provide public services on transport/vehicles for mountains, (iii) construct storage houses, (iv) construct irrigation facilities, and (v) build climate-resilient infrastructure.	
Sloping land	(i) Disseminate suitable farming technologies, (ii) promote terrace farming, contour farming, hedgerow planting and strip cropping, (iii) enhance diversification and proper agricultural production systems combined with productivity-enhancing technology packages that could help reduce soil and water runoff, (iv) promote sediment trapping to create fertile lands along gullies and streams, and (v) promote and incentivise sloping land management technologies.	India: cultivation of apple and other horticulture crops on highlands with a slope of more than 20 percent in Himachal and Jammu and Kashmir.
Climate change	(i) Prevent deforestation by growing local varieties of large trees, (ii) adopt Climate Smart Agriculture (CSA), (iii) practice climate-resilient and climate adaptation agriculture planning, (iv) develop early warning systems and broadcast to potential stakeholders, (v) promote diversification, (vi) increase research on climate resilience, and (vii) provide crop insurance.	
Low productivity	(i) Identify and promote improved crop varieties, (ii) develop seed industry and encourage formation of community seed grower associations or cooperatives, (iii) promote crop diversification and short-duration crops, introduce double cropping, spring crop promotion, winter cropping, year-round cropping and protected agriculture technologies, (iv) strengthen research and development (R&D), identify effective and sustainable farming practices and techniques that can help improve productivity in various agricultural production systems in high and sloping lands, (v) establish effective agriculture extension, disseminate needs-based R&D results.	Myanmar: multiplication of certified seeds by seed grower farmers organized by the DOA and Seed Bank Program.
Lack of R&D	(i) Increase public expenditure and investments on needs-based research R&D, (ii) increase policymakers awareness of the need for R&D, (iii) develop national agriculture R&D systems and promote networking and collaboration among research institutions, R&D centres and higher education institutions, and (iv) conduct on-farm research activities in mountain areas in consultation with local farmers.	Myanmar: joint on-farm research activities by extension and research departments.
Lack of extension services to disseminate technology and improve capacity	(i) Establish or strengthen national agricultural extension systems, (ii) involve higher education institutions, (iii) build capacity for extension service providers, (iv) improve extension services using the PPP model, (v) use alternative methods for information dissemination include ICT, and (vi) develop pluralistic extension services.	Bhutan: extension agents are placed in every district and sub-district across the country. Nepal: restructuring of agriculture and livestock extension in 753 local governments has been initiated.
Lack of information on important major agricultural commodity groups with high potentials in mountains	(i) Identify potential Future Smart Food species in mountains, (ii) conduct research on diversification and proper agricultural production systems combined with productivity-enhancing technology packages, (iii) disseminate R&D information through extension service systems to farmers, (iv) disseminate information by governments and NGOs using ICT, public media, and awareness activities, and (v) establish demonstration center.	Nepal: regional and district FM, television and ICT.

Annex 3 Suggested solutions to address multi-dimensional challenges on mountain agriculture (2): Socio-economic constraints

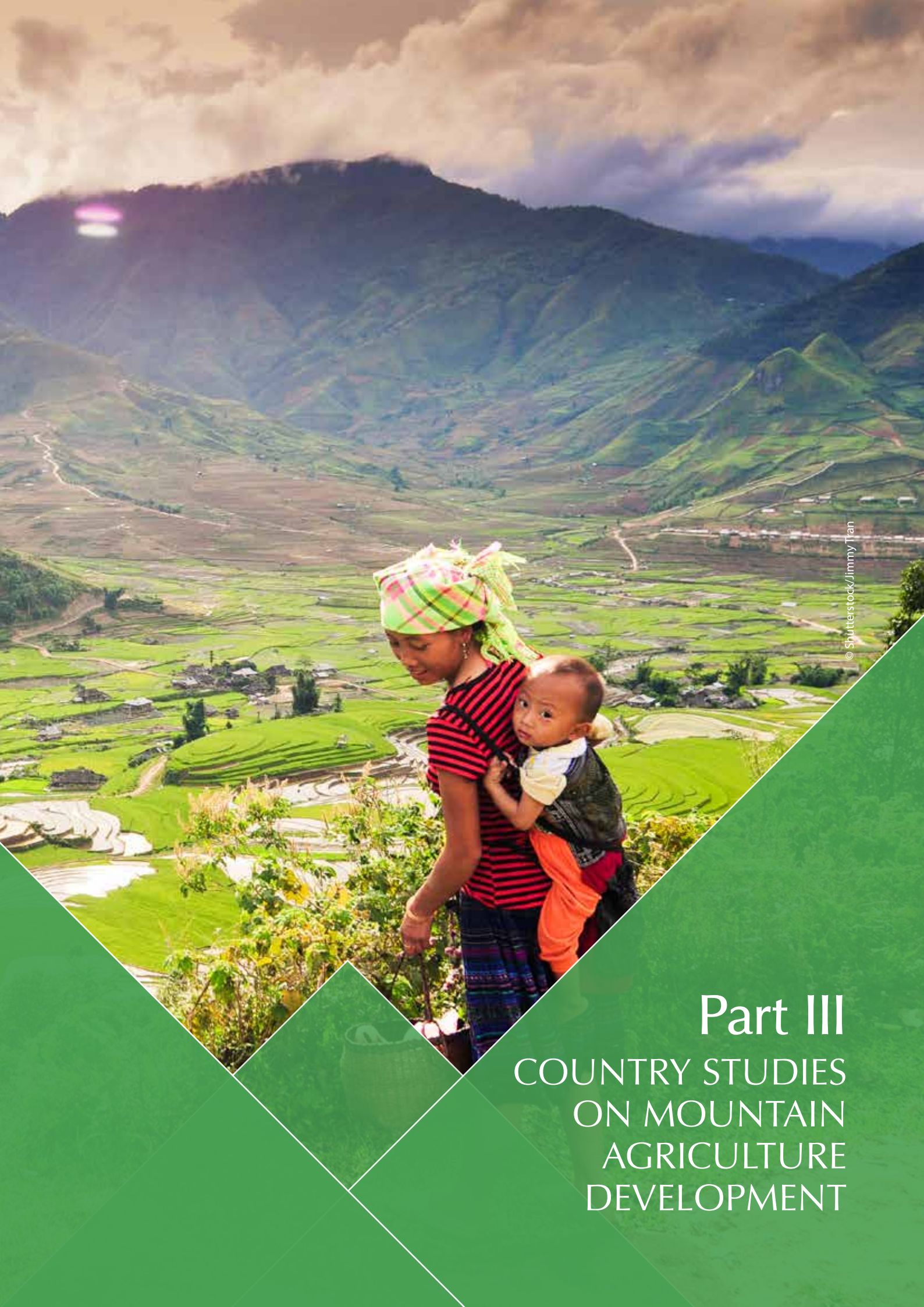
Main constraints	Suggested entry points and solutions	Examples
Lack of market information and poor access to telecommunications*	(i) Develop real time and dynamic market information systems by public sector, (ii) establish policy on infrastructure development, (iii) enhance extension services for information, and (iv) use ICT including Internet and mobile devices to ensure that market information and intelligence is available to local users at all levels of the agrifood sector, and link research and extension services personnel to farmers through ICT as information provider.	India: improved telecommunication facilities through country, and access at affordable rates.
Isolation and lack of market access/ transport network*	(i) Prioritize transportation facilities for mountain areas to improve connectivity (quality road, airports, ports), (ii) provide public services on transport/vehicles for mountains, (iii) build market infrastructure, (iv) build capacity for market infrastructure management, (iv) develop market intelligence and build capability on access to markets, (v) make use of ICT, and (vi) fair pricing mechanisms.	Shan State, Myanmar: Build-Operate-Transfer (BOT) system in road development. India: development of Special Economic Zones (SEZ) for agricultural commodities.
Lack of defined land tenure rights	(i) Establish temporary rights for land use, (ii) establish customary rights and recognize rights of indigenous communities in mountain areas, (iii) institutionalize contract farming, and (iv) advocacy.	Bhutan: land act provides equal access and individual rights to land ownership and periodic land reforms by the State.
Aging society and lack of manpower/ urban migration	(i) Develop agriculture as a profitable enterprise to encourage young people to remain. This could be achieved by (a) promoting technology package to enhance productivity of smallholders, (b) modernizing agriculture with high-value crops to enhance incomes and involve smart technology to attract youth, (c) applying appropriate mechanization, and (d) improving infrastructure, (ii) promote modern and contract farming with land consolidation that is supported by better targeted incentives and subsidies, gender friendly mechanization services, and enhanced service delivery of inputs, and (iii) establish agriculture programmes focused on youth.	India: reduced rural migration by improving road and market infrastructure through Pradhan Mantri Sadak Yojana.

Annex 4 Suggested solutions to address multi-dimensional challenges on mountain agriculture (3): Policy constraints

Main constraints	Suggested solutions	Examples
Lack of information on mountain speciality products*	(i) Identify mountain speciality products by reviewing existing data on mountain agriculture and forest biodiversity in terms of nutrition density, climate resilience, economic variability and local availability, (ii) coordinate/build/connect communication channels to disseminate information and popularize special or niche mountain produce in public, (iii) organize awareness-raising and promotional activities on mountain products nationally, regionally and internationally.	Myanmar: information can be sourced from Myanmar Agri-Business Journal, newspapers, TV channels, farmer channel and the National Races Channel
Lack of targeted policy support for promotion mountain speciality products	(i) Establish national strategy and policy as well as programmes that promote mountain speciality products, (ii) organize promotional activities for mountain speciality products and link smallholders to markets, (iii) provide support and build capacity of smallholders on packaging, quality assurance, brand-building, labelling for mountain speciality products.	OVOP; GIAHS
Lack of empowerment of mountain communities in decision-making processes	(i) Agricultural research and development needs to be farmer-driven and pro-poor and there needs to be a balance between top-down and bottom-up approaches, (ii) initiatives in mountains should be discussed with communities or stakeholders prior to implementation through (a) participatory community planning, (b) community management of common resources, (c) enhanced capabilities of communities through training, and (d) enhanced social empowerment awareness.	

Annex 5 Suggested solutions to address multi-dimensional challenges on mountain agriculture (4): Institutional constraints

Main constraints	Suggested entry points and solutions	Examples
Lack of organized institutional support to connect production, processing, marketing and consumption for mountain products*	(i) Establish a national knowledge centre on mountain speciality products with detailed information on products and producers, including nutrient value, (ii) disseminate information on mountain products and producers to interested stakeholders (processors, transporters, traders, consumer associations and chefs), (iii) establish agro-processing centres close to mountains, (iv) build capacity for packaging of mountain products, (v) build public transportation facilities between mountains and agro-processing centres and markets, and (vi) organize promotional activities on mountain products with good market links nationally, regionally and internationally connecting producers and consumers.	
Lack of investment for institutional support	(i) Establish a dedicated agribusiness and marketing division under the Ministry of Agriculture and Ministry of Trade and Commerce, respectively, and strike both for streamlined coordination, (ii) strengthen networking and collaboration for resources mobilization for mountain agriculture development, and (iii) initiate and implement special programmes for mountains by the government in coordination with NGOs.	
Lack of promotional activities for mountain agriculture products	(i) Conduct regular agriculture fairs, branding of mountain products, and organize trade promotion visits, (ii) cooperate with international commerce associations, international organizations and development partners, (iii) collect and disseminate scientific data about FSFs from mountains in the public domain via ICTs, and (iv) increase awareness of nutritional and ecological benefits of mountain products and certification.	Thailand: Government promotes brands and organizes national and international agriculture trade fairs benefiting mountain producers on a large scale.



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Part III

COUNTRY STUDIES ON MOUNTAIN AGRICULTURE DEVELOPMENT



9 Bangladesh

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9.1 Overview

9.1.1 Physical characteristics

Bangladesh is in the north-eastern part of South Asia and covers the the biggest delta in the world. The majestic Himalayas stand some distance to the north, while the Bay of Bengal is to the south. The west is bordered by West Bengal and the hilly and forested regions of Tripura, Mizoram (India) and Myanmar lies to the east. These picturesque geographical boundaries frame a low lying plain that is crisscrossed by innumerable rivers and streams leading to Bangladesh being known known as the “Country of Rivers”.

Bangladesh offers many tourist attractions, including archaeological sites, historical mosques and monuments, the longest natural beach in the world, picturesque landscapes, hill forests and wildlife, rolling tea gardens, colourful tribes and a mosaic of culture. The rich flora and fauna and and cultural attractions enchanting. Each part of the country offers distinctly different topography, flavours and delicacies.

Bangladesh lies from 20° 34' to 26° 38' N latitude and 88° 01' to 92° 41' E longitude. Bangladesh Shares 3 976 km borders with India to west, north and east, 270 km borders with Myanmar and has 580 km coastline on the Bay of Bengal to the south. The country is surrounded by the Indian states of West Bengal, Assam, Meghalaya and Tripura to the west, north and east respectively, 3 976 km altogether, Myanmar is to the south with 270 km territory, of which 93.90 percent is shared with India and about 6.10 percent with Myanmar. The Bay of Bengal has 580 km of shoreline in the south.

Bangladesh has a tropical climate with mild winters from October to March, and hot, humid summers from March to June. The country has never recorded an air temperature below 0°C (32°F). Its record low of 1.1°C (34.0°F) in the was recorded in the north-west city of Dinajpur on 3 February 1905. The warm and humid monsoon season lasts from June to October and supplies most of the country's rainfall. Natural calamities, such as floods, tropical cyclones, tornadoes, landslides,

Figure 9.1 Map of Bangladesh



heavy rainfall, flash floods, droughts and tidal bores occur almost every year, while with the effects of deforestation, soil degradation and erosion are increasingly felt across the land.

Although Bangladesh has a huge population and many new industries, agriculture remains the largest employment sector, providing work for 49.1 percent of the total workforce and contributing 14.10 percent of the GDP (Economic Review, 2018).

The agriculture sector has an overwhelming impact on major macroeconomic objectives such as employment generation, poverty alleviation, human resources development and food security. The main crops are rice and jute, but wheat is becoming increasingly important. Tea is grown especially in the northeast hills, along with potatoes, sugarcane and various vegetables. Generally, the farmers use ancient traditional farming systems.

Table 9.1 Population of the CHT vs nationals

Mountain vs national	Area (km ²)	Household	Population			HH size	Sex ratio	Population per km ²
			Male	Female	Total			
CHT	13 295	342 390	864 072	799 202	1 663 274	4.67	108.1	120
Bangladesh	147 570	32 173 630	74 980 386	74 791 978	149 772 364	4.44	100.3	1 015

Source: BBS, 2012

Figure 9.2 Climate zones of Bangladesh

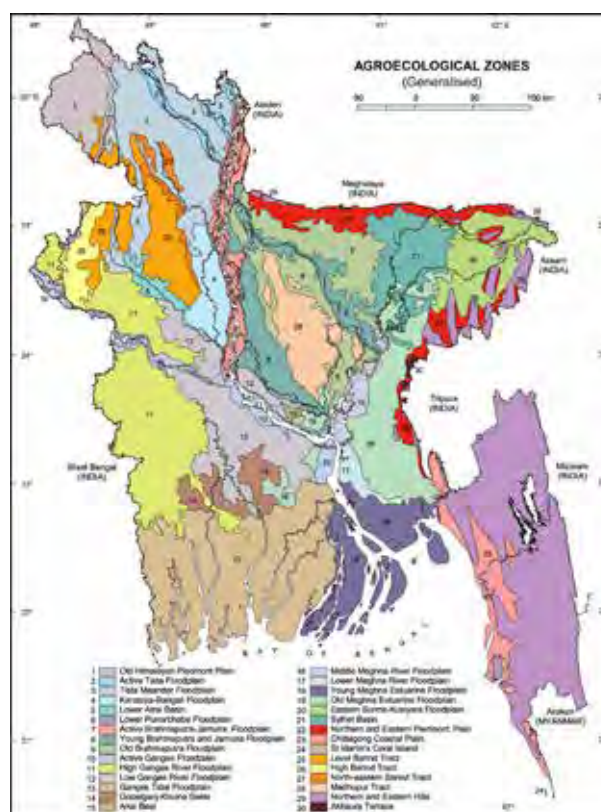
However, more recently, they have started using modern technologies and producing more crops as a result. Scientists and researchers have been working on developing new technologies to increase production. Nuclear agriculture (which uses isotopes and radiation techniques to fight pests and diseases, increase crop production, ensure food safety and authenticity, and increase livestock production) has added a new dimension to Bangladesh agriculture. The Bangladesh Institute of Nuclear Agriculture (BINA) has already developed 37 crop varieties.

9.1.2 Demographics

Bangladesh is the 8th most populous country in the world (with 160 million people) and one of the most densely populated (1 090 persons/km²). There are

104 males for every 100 females. The intercensal rate of population growth is 1.37 per annum and the literacy rate is 72.26 percent (UNESCO, 2016, BBS, 2018).

Bangladesh has many diverse small ethnic communities (SECs) that can be broadly categorized into two groups based on their origin and level of exposure to “modernity”: (1) the Tougtha (also known as the Kuki Group) include the Kuki, Khumi, Mro, Lushai, Khyang, Banjogi and Pankh; and (2) the Khyongtha (also known as the Tipra group) include the Chakma, Marma, Tipra, Tangchangya and Rieng. The Tougthas are considered “ancient tribes” while the Khyongthas are the “domiciled tribes” (Lewin, 1869).

Figure 9.3 Agro-ecological conditions of Bangladesh

9.1.3 Economy

While Bangladesh suffers from poor rural infrastructure, the situation has drastically improved as a result of robust economic growth, maintaining more than 6 percent growth from 1996–2016, and well over 7 percent in recent years. Bangladesh's economic growth has been termed the “miracle of the east” due to its growing economic power.

In 2017, Bangladesh's nominal GDP was calculated at USD286 billion, growing at a rate of 7.65 percent, making it the 43rd largest, and second fastest growing economy in the world (Economic Review, 2018).

9.1.4 Hunger and all forms of malnutrition

In Bangladesh, around one-third of the population is under 15 years of age (UNICEF, 2017; NIPORT *et al.*, 2016). Bangladesh has maintained an impressive track record of 6 percent economic growth rate over the past decade, coupled with remarkable improvements in human development (World Bank, 2017). Agriculture and fisheries are the main pillars of the economy, employing more than half the population (USAID, 2017a). (USAID, 2017a). Malnutrition in children and pregnant women has many adverse consequences for child survival and long-term well-being as well as far-reaching consequences for human capital, economic productivity, and national development. In Bangladesh, about 5.5 million children under 5 years (36 percent) suffer from chronic malnutrition (stunting or low height-for-age) and 14 percent are acutely malnourished (wasting or low weight-for-height) (USAID, 2018).

Malnutrition in Bangladesh is caused by multiple factors including disease and inadequate food intake. The underlying causes of malnutrition include the inability of households to grow and/or purchase sufficient food for their needs, poor maternal and childcare practices, including inadequate breastfeeding and complementary feeding for infants and young children. Another factor is inadequate provision of food for adolescent girls and pregnant and lactating women. These are compounded by delays in recognizing the signs of malnutrition or disease and in seeking care for children and women, inadequate access to quality health services, including family planning, immunization and medical services, and poor access to sanitary facilities and potable water.

Food security and adequate nutrition are among the basic needs of every human being. Their fundamental importance has been underscored by the world community through the International Covenant on Economic, Social and Cultural Rights (ICESCR), which enshrines the right to food and adequate nutrition, as inalienable rights that every human can claim. It also makes economic sense to pay attention to food security and nutrition. No country can expect to build a thriving economy on the backs of hungry and undernourished people. According to a joint study of the Government of Bangladesh and the USAID undernutrition already costs Bangladesh more than USD 1 billion in lost productivity every year and even more in health costs. This means that, if Bangladesh aspires to be a developed country by 2041 (as the government has proclaimed), it must commit to investing heavily and effectively in food security and nutrition. This strategic review is intended to strengthen the efforts of the government in this regard. In so doing, the review takes a medium-term outlook that is consistent with the timeframe of the Sustainable Development Goals (SDGs), which are targeted to be achieved by the year 2030 (WFP, 2016).

9.1.5 Poverty

Poverty in Bangladesh has declined remarkably since the early 2000s due to decades of accelerated economic growth. The remarkable progress in poverty alleviation has been recognized by international institutions.

Table 9.2 Poverty headcount ratio

Place	2010 (%)	2016 (%)
National	31.5	24.3
Urban	21.3	18.9
Rural	35.2	26.4

Source: BBS, HIES-2016.

According to the World Bank, Bangladesh's poverty rate fell from 82 percent in 1972 to 18.5 percent in 2010 and 13.8 percent in 2016, as measured by the percentage of people living below the international extreme poverty line. Based on the current rate of poverty reduction, Bangladesh is projected to eliminate extreme poverty by 2024 and become the only upper-middle income economy in the South Asian region, according to the World Bank.

9.2 About Mountains in Bangladeshaesh: The Chattogram Hills Tracts (CHT)

9.2.1 Location

The CHT region comprises three hill districts – Rangamati, Bandarban and Khagrachari – in the south-eastern part of Bangladesh. It covers an area of 13 295 km² that is geographically, topographically and ecoculturally different from the plains.

Figure 9.4 Location of the CHT in Bangladesh



9.2.2 Administrative unit

Parallel to the government administrative system, there is a traditional administrative system in this region that can be divided into three circles. Each circle corresponds with current district boundaries and is divided into numerous *mouza* (unit of revenue administration) led by a Headman, with each *mouza* subdivided into *inparas* (villages) led by a *Karbari* (traditional chief of a village).

The three traditional administrative circles are the *Mong* (Khagrachhari), *Chakma* (Rangamati) and *Bohmong* (Bandarban), each with a traditional chief.

9.2.3 Demographic features

According to the Population and Housing Census 2011, the CHT region has a total area of 13 295 km², 342 390 households and about 1.7 million people (Table 9.5). The population density per km² is much lower in CHT (120) than Bangladesh (1015) (BBS, 2012). The per capita land endowment seems much higher in the CHT than the rest of the country, but it is in fact the lowest in terms of available plain land.

The average number of persons per household in CHT is 4.7, which is higher than the national average of 4.4. There are more men than women, which is possibly due to high female mortality and/or a high degree of male in-migration. About 30 percent of people in CHT are urban dwellers.

9.2.4 Ethnicity

The CHT is the home of numerous SECs, representing just over 1 percent of the total population. There are 29 official ethnic groups across the country, which are concentrated in CHT. It is believed that most of the ethnic groups are of Sino-Tibetan origin, including the Chakma (Changma), Marma (Magh), Tripura (Tippera), Bawm (Banjogi), Chak (Asak), Khyang, Khumi, Lushai (Kuki), Mro (Murang), Pangkhua (Pankho) and Tanchangya.

9.2.5 Landforms and elevation

Six major landforms have been identified in the CHT:

- ◆ Medium-gradient mountains
- ◆ High-gradient hills
- ◆ Medium-gradient hills
- ◆ Dissected plains
- ◆ Plains
- ◆ Valleys

Table 9.3 Distribution of administrative units in the CHT in Bangladesh

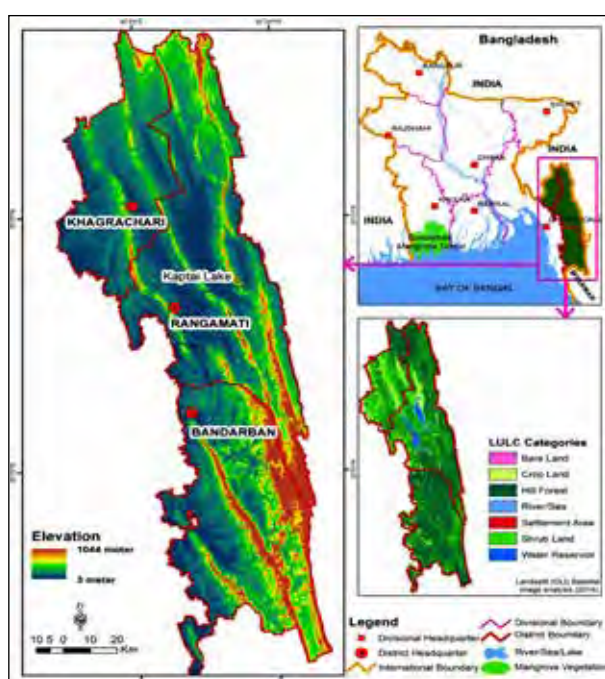
Administrative unit	Bandarban	Khagrachhari	Rangamati	Total
Upazila	7	8	10	26
Union	33	38	50	121
Mouza	96	120	162	378
Village	1 554	1 702	1 555	4 811

Source: BBS, 2018

Table 9.4 Demographic profile of the CHT in Bangladesh

District	Area (km ²)	Household	Population			HH size	Sex ratio	Population per km ²
			Male	Female	Total			
Bandarban	4 479	80 102	211 628	192 465	404 093	4.75	110.0	87
Khagrachhari	2 700	133 792	326 621	312 346	638 967	4.59	104.6	227
Rangamati	6 116	128 496	325 823	294 391	620 214	4.53	110.7	97
CHT	13 295	342 390	864 072	799 202	1 663 274	4.67	108.1	120
Bangladesh	147 570	32 173 630	74 980 386	74 791 978	149 772 364	4.44	100.3	1 015

Source: BBS, 2012

Figure 9.5 Landforms and elevation of the CHT in Bangladesh

Source: Emran A, *et al.*, (2018)

Primary elevation data of the study area was extracted from maps of the Survey of Bangladesh (SoB) and the Bangladesh Water Development Board (BWDB). Elevations are updated using SRTM (Shuttle Radar Terrain Model) datasets (90 m digital elevation model developed by United States Geological Survey (USGS) in 2003). All spot heights are converted in meter Public Works Department (PWD) datum. The maximum elevation of the CHT is 1 027 m PWD. About 79 percent of the study area lies between 0 and 200 m PWD (Table 9.5).

9.2.6 Land cover

Land cover includes forest, herb/shrubs, fallow/ agricultural land, river and water bodies, settlements, hill shades etc. The land cover in CHT is shown in table 9.7.

9.2.7 Land use

Land capability classification adopted for the CHT is based on the depth of soil and slope of the land. The land capability assessment for the CHT shows the proportion of different classes as follows:

- ◆ Class A: good agricultural land (3.2 percent);
- ◆ Class B: moderate agricultural land (2.8 percent);
- ◆ Class C: poor agricultural land (15.6 percent); and
- ◆ Class D: very poor non- agricultural land (78.4 percent).

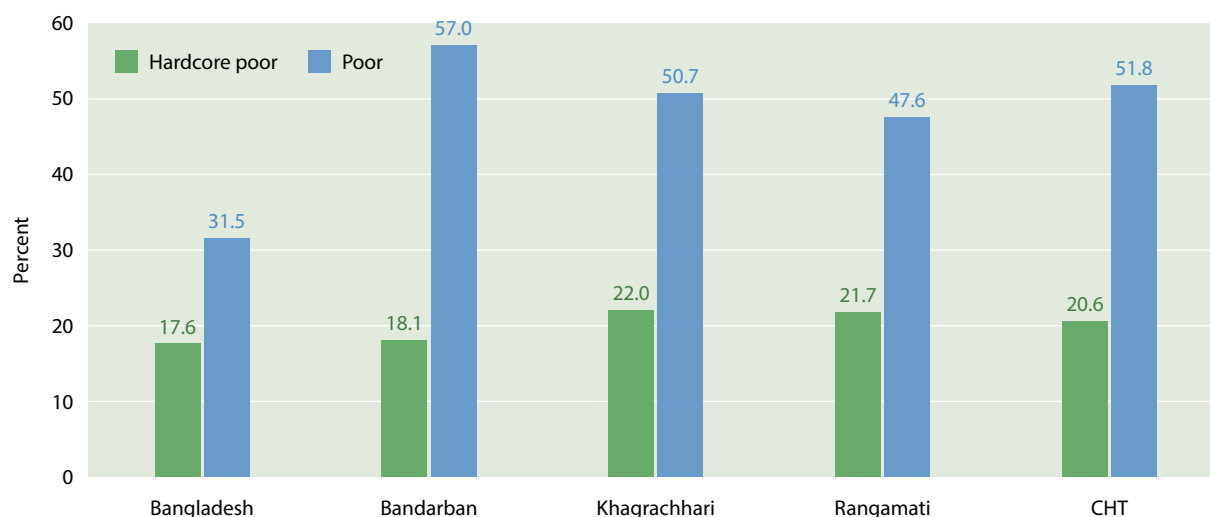
Five classes of land are distinguished according to land capability (Forestral, 1966). Based on satellite images, lands are grouped in seven categories according to slope gradient.

9.2.8 Livelihoods status

There is much less variety of jobs in the CHT when compared to the national picture. This lack of scope means that poverty is widespread through the region. Figure 9.1 shows the comparison between the nationals vs CHT region.

9.2.9 Key Characteristics of mountain regions in Bangladesh

- ◆ Tribal inhabited area
- ◆ Traditional administrative system
- ◆ Rich and diversified cultural heritage

Figure 9.6 Poverty status of nationals vs the CHT in Bangladesh

Source: CHTDF; UNDP, 2014

Table 9.5 District wise land under different elevations in the CHT in Bangladesh

Elevation (m PWD)	Area (ha)		
	Bandarban	Khagrachhari	Rangamati
1–100	192 599.8	197 599.4	317 673.1
101–200	114 216.9	75 415.6	145 666.3
201–300	60 648.2	13 089.1	56 979.1
301–400	36 197.7	2 502.7	26 069.9
401–500	23 106.2	386.9	12 342.7
501–600	16 838.5		7 224.8
601–700	10 006.5		5 362.4
701–800	4 281.9		3 508.2
801–900	1 495.8		984.4
901–1000	142.3		79.3
1001–1100	11.3		

Source: CEGIS, 2012

Table 9.6 Gradient of CHT hills in Bangladesh

Slope (%)	Area (ha)	Suitability	Area (ha)
0–5	270 812 (plain to gentle)	All purposes agriculture	20.45
6–10	298 221 (gentle to moderate)	Contour planting of horticulture and spice crops	22.52
11–20	369 892 (moderate to steep)	Mostly horticulture and partly forest	27.93
21–30	198 710 (steep to moderately steep)	Mostly forest and horticulture	15.00
31–50	150 506 (moderate to high steep)	Horticulture, spices and forest plants	11.32
51–70	29 622 (high to very high steep)	Forest species and medicinal plants	2.24
>70	6 665 (very high steep)	Forest species	0.50
Total	1 324 428		100.00

Source: CEGIS, 2012

- ◆ Predominantly agrarian
- ◆ Agroforestry predominates
- ◆ Topographically remote, inaccessible and fragile
- ◆ Low level of literacy
- ◆ Low human resource development index
- ◆ Poor livelihood.

9.2.10 Climate

The CHT region has a subtropical monsoon climate. The monsoon season proper lasts from June to September. The monsoon season is preceded and followed by transitional periods during which occasional rains occur, often thunderstorms. Tropical heavy rainfall can damage property and crops. The cool dry season lasts from November to February. Temperatures range

Table 9.7 Land cover in the CHT in Bangladesh

Land cover	Area (ha)	% of total Area
Dense forest	78 596	5.9
Medium Dense forest	230 753	17.4
L. Dense forest	413 869	31.2
Herb Shrub Grass	390 910	29.5
Fallow/Agri. Land	78 099	5.9
River & Water	64 474	4.9
Settlement	55 162	4.2
Hill Shades	12 181	0.9
Others	376	0.1
Total	1 324 420	100.0

Table 9.8 Classification of land by crops suitability in the CHT in Bangladesh

Slope (%)	Area (ha)	Suitability	Area (ha)
0–5	270 812 (plain to gentle)	All purposes agriculture	20.45
6–10	298 221 (gentle to moderate)	Contour planting of horticulture and spice crops	22.52
11–20	369 892 (moderate to steep)	Mostly horticulture and partly forest	27.93
21–30	198 710 (steep to moderately steep)	Horticulture, spices and forest plants	15.00
31–50	150 506 (moderate to high steep)	Forest species and medicinal plants	11.32
51–70	29 622 (high to very high steep)	Forest spices	2.24
>70	6 665 (very high steep)		0.50
Total	1 324 428		100.00

Source: CEGIS, 2012

Table 9.9 Season wise average rainfall distribution in the CHT in Bangladesh

District	Winter (Dec–Feb)		Pre-monsoon (Mar–May)		Monsoon (Jun–Sep)		Post-monsoon (Oct–Nov)		Annual rainfall (mm)
	Area (mm)	(%)	Area (mm)	(%)	Area (mm)	(%)	Area (mm)	(%)	
Khagrachhari	28	1.2	437	17.9	1 761	72.4	207	8.5	2 433
Rangamati	28	1.1	435	17.1	1 863	73.4	212	8.4	2 538
Bandarban	30	1.0	411	13.9	2 270	76.5	256	8.6	2 966

Source: DAE

from 25–35°C and humidity ranges from 65 percent in the dry season to 90 percent in the monsoon season, but night time humidity is high for most of the year.

9.2.11 Rainfall

The mean total annual rainfall in the CHT ranges from 2400–3000 mm. The Bandarban district experiences the most rainfall while the other two districts have similar

rainfall distribution. Monsoon season rainfall is approximately 70–80 percent of the annual rainfall in the CHT.

9.2.12 Biodiversity

CHT has a unique biodiversity of flora and fauna. The hills, valleys, forests, lakes, water streams, waterfalls, birds and animals play a vital role in maintaining this

Table 9.10 Population figures for three districts of the CHT classified according to the four IPC chronic food insecurity levels in Bangladesh

District	Population	Level 1	Level 2	Level 3	Level 4	Level 2 or higher ratio	U5 mortality rate
Bandarban	429 949	107 000	118 000	97 000	86 000	301 000	84
Khagrachhari	652 326	228 000	228 000	130 000	65 000	423 000	31
Rangamati	634 250	235 000	222 000	140 000	38 000	400 000	71
Total	1 716 525	570 000	568 000	367 000	189 000	1 124 000	

Source: IPC Chronic Food Insecurity Situation in ten districts of Bangladesh – December 2015-2018/20; The Food Planning and Monitoring Unit (FPMU) of the Ministry of Food of Bangladesh in collaboration with country IPC Partners.

biodiversity. Kaptai Lake holds water all year and contains many types of aquatic animals. In winter, seasonal birds come from outside the country and also attract tourists. Bamboo is one of the main forest products. Bamboo plantations and conservation help to keep the environment eco-friendly by absorbing more carbon than other trees. Deer, monkeys, elephants, bears and snakes are the major wild animals of CHT.

9.2.13 Hunger, Food Security and Nutrition Status

Rice is the staple food for all households in CHT. Food habits, reflected in food items consumed by CHT communities, are similar to those of the plains people apart from a few items such as *nappi* (a special type of dry fish), bamboo shoots and dry vegetables. The physical quantity of daily food intake per person in CHT is about 718 g. More than 50 percent of food intake comes from rice followed by vegetables which make up around 30 percent. According to the Cost of Basic Need (CBN) CBN method, slightly less than three-fourths of households (74 percent) live below the lower poverty line (taka 866/person/month) and 86 percent of households live below the upper poverty line (taka 1025/person/month). The poverty status of women in rural CHT is a grave concern, with almost all women in CHT (94 percent) living below the absolute poverty line and about 85 percent below the hardcore poverty line. In terms of the energy intake of food, people living in rural CHT used to have 1 798 kcal per day, which is less than the hardcore poverty line (below 1 805 kcal) (Talukder and Paul, 2013).

Food insecurity is chronic in the CHT region and deteriorates from March to August/September between planting and harvesting, according to Key Informant Interviews. The lean season occurs from May to August; however, due to the high risk of natural hazards during the monsoon, this often extends to September. Due to increasing land scarcity and a decline in resources, each year it is more difficult for people to cope with the

lean season, as food stocks from the previous harvest run low, employment opportunities are limited and purchasing power is low. The monsoon season (May–September) further impacts food insecurity as heavy rainfall leads to flooding and landslides, which can severely damage crops. The worst affected areas are usually Thanchi Upazila in the Bandarban district and Sajek Union in the Rangamati district. The Bandarban district has been classified as severely food insecure with the population facing Integrated Food Security Phase Classification (IPC) Phase 4, and the Rangamati and Khagrachhari districts are classified as IPC Phase 3 (Chronic IPC Analysis, 2015). Geographic remoteness has been identified as a major driver of social disparity in the CHT, despite increased efforts to reach these remote areas. Malnutrition rates in Bangladesh are among the highest in the world. It is said that approximately 50 percent of children below five years age are underweight and stunted. Like other parts of Bangladesh, the forms of malnutrition in the CHT are low birth weight, underweight, stunting, and deficiencies of vitamin A, iodine and anaemia.

Of the 64 districts in Bangladesh, 28 have undergone two rounds of IPC Chronic Food Insecurity Analysis. These 28 districts are mainly located in the North, Coastal Belt, North Eastern Haor (low lying areas that remain under water for nearly half of the year) and the CHT or hill tracts where higher levels of poverty, undernutrition and vulnerability to disasters prevail. The second round covered ten districts – six in Haor areas (Sunamgonj, Netrakana, Moulvibazar, Habiganj, Kishorgonj and Sylhet), three in CHT (Bandarban, Rangamati and Khagrachhari) and one in the Coastal Belt (Cox's Bazar). Of the ten districts, six have a very high prevalence of food insecurity. The Sunamganj and Bandarban districts are the most of the most concern and were classified as having severe Chronic Food Insecurity (CFI) (Level 4). The other eight districts were classified as moderate CFI (Level 3) and was higher in south-eastern CHT districts than in north-eastern Haor districts. No districts were classified as mild CFI (Level 2)

Table 9.11 Overview of mountain agriculture and FSN in Bangladesh

Socio-economic	Population	Nation	149 772 364
		Mountain areas	1 716 525
	Food insecurity	Nation	
		Mountain areas	14%
	Malnutrition	Nation	
		Mountain areas	USD 286 billion
Agroclimatic	GDP	Nation	
		Share of GDP of mountain agriculture in country	
	Total land/areas in mountain areas	13 295 sq km	
	Distribution of mountain land/areas in country: Major regions/districts/provinces	Southeast	
	Land utilization in the mountain areas (used vs fallow/wild land)	20% used	
	Altitude (range)	Several meters to 1 000 meters above sea level	
	Latitude (range)	In between 21° 25' N and 23° 45'	
	Longitude (range)	91° 54' E to 92° 50' E	
	Soil type	Yellowish brown to reddish brown loams	
	Minimum temperate (average)	12°C	
	Maximum temperate (average)	35°C	
Agriculture	Rainfall	3 500 mm	
	Crop grown period	Year round (Mainly April-September)	
	Main crops	Paddy, banana, potato, papaya, pine apple, malta, jackfruit, different taro/yam, turmeric, ginger, maize, sugarcane, vegetable, orange, mango, water-melon etc.	
Forestry	Minor crops	Jhum chili, malta, kul, pomelo, coffee, cashew nut, coconut etc.	
	Main cash crops	Ginger, turmeric, sugarcane, different types of fruits etc.	
	Non-timber product	Broom grass, bamboo, cane etc.	
Forestry	Main medicinal plants	Amla (Phyllanthus emblem), Neem (Azadirachta Indica), Haritoki (Terminalia chebula), Basak (Justicia adhatoda) etc.	

Source: DAE, Rangamati 2019

or minimal CFI (Level 1) (Integrated Food Security Phase Classification IPC Report, 2016). The percentage of the population classified as Level 3 and above is highest in Bandarban and Sunamganj (40 percent) followed by Netrakona, Habiganj, Khagrachhari and Rangamati (around 30 percent).

9.3 Mountain agriculture in the CHT: Present status, challenges and constraints

The hilly and mountainous areas differ from the plains in topography, elevation, physiographic features, diversity of habitats for flora and fauna, ethnic diversity, land use systems and socio-economic conditions. Hills,

in general, offer a vast scope for cultivation of diverse mix crops-cereals, pulses, oilseeds, vegetables, flowers, fruits and animal husbandry is an integral part of farming system. Temperature and climatic conditions support growth of some fruits and vegetables crops, which otherwise cannot be cultivated in plains and produce provides higher dividends to growers in hills thereby raising their economic status.

9.3.1 Land utilization in the mountain areas

Agriculture is the main source of income for most of the population. *Jhum* or swidden farming is traditional agriculture practised by indigenous communities. Land use pressure coupled with deforestation, landslides, timber, bamboo and non-timber forest product (NTFP)

Table 9.12 Description of agricultural lands in the CHT in Bangladesh

Description	Rangamati	Khagrachhari	Bandarban	CHT total (ha)
Area	611 600	270 000	447 903	1 329 503
Net cultivated land	50 372	44 030	35 520	129 922
Single crop land (ha)	23 872	22 820	20 119	66 811
Double crop land (ha)	23 070	188 780	12 931	54 781
Triple crop land (ha)	3 430	2 430	2 470	8 330
Fallow land (temporary)	10 963	6 581	5 153	22 697
Fallow land (permanent)	5 262	1 744	78 600	85 606
Total crop land (ha)	80 302	67 670	53 391	201 363
Cropping Intensity (%)	159	154	150	155
Horticultural crop land (ha)	37 347	16 364	45 897	99 604
Forest (ha)	469 872	141 330	273 050	888 980
Kaptai Lake (ha)	58 300	0	0	58 300

Source: DAE, 2018

extraction has decreased the *jhum* rotation period from 7–10 years (up to 20–25 years) to 3–5 years, with 95 percent of the land not suitable for intensive agriculture. Areas previously considered unsuitable for *jhum* are now under cultivation. Steeper land is being used with greater intensity, resulting in topsoil erosion, loss of soil productivity and depletion of water resources.

The CHT area covers vast tracts of forest land, a wide range of hills and alluvial valley bottoms. Cultivable plain land is scarce in the CHT region. Land suitable for intensive field crop cultivation is less than 5 percent of the total area. The traditional agricultural economy is based on growing paddy and other crops in the valley bottoms. The utilization of hill slopes by shifting cultivation is locally known as *jhum*. During the construction of the Kaptai dam in 1960 for a hydroelectricity project, around 60 000 acres of cultivable plain land was submerged in Kaptai Lake. Along with its remoteness or lack of market accessibility, the absence of natural security affects the development of horticulture and other tree crops. Much of the land of indigenous people is unregistered and liable to be lost to immigrants, particularly where road networks are developed. This insecurity of tenure reduces the incentive for medium- to long-term investments, such as horticulture or timber. Instead, short-term investments in seasonal crops are promoted, which do not provide high incomes for households and are not environmentally beneficial. Large tracts of the CHT region are covered by hills, which make it unique in terms of agricultural practices and livelihood patterns. Most of the people

depend on agriculture for their livelihood. The current situation is largely characterized by an increasing population, water scarcity in the dry season, land degradation, and weak market links.

9.3.2 Main farming systems in mountain areas

- ◆ Upland *Jhum* cultivation system
- ◆ Ploughland farming system
- ◆ Homestead cultivation system
- ◆ Horticulture farming system
- ◆ Fruit and tree crop farming system
- ◆ Mixed orchard farming system
- ◆ Vegetable farming system
- ◆ Fringe-land farming system
- ◆ Forestry farming system
- ◆ Forest product wood production farming system
- ◆ Rubber plantation production system
- ◆ Agar plantation production system
- ◆ Wild product production system (Broom grass, *Thysanolaena maxima*; Bamboo, *Bambusa arudinaceae*)
- ◆ Domestic animal production system (livestock and poultry)
- ◆ Aquaculture fish farming system

Table 9.13 Fruit production in the CHT in Bangladesh

Fruit	2013–14		2014–15		2015–16	
	Area (ha)	Production (MT)	Area (ha)	Production (MT)	Area (ha)	Production (MT)
Mango	9 549	128 030	10 082	150 264	10 955	148 130
Litchi	4 194	25 881	4 402	26 954	4 695	31 769
Malta	374	2 855	405	3 058	531	4 298
Jackfruit	9 800	244 003	9 903	247 245	10 218	260 198
Lemon	2 052	27 532	2 095	28 087	2 100	30 787

Source: AD, DAE 2017

9.3.3 Major livelihood activities

9.3.3.1 Crops

Upland Jhum farming is based on mixed cropping. Seeds are sown in May. Rice, corn, vegetables, sesame and turmeric are common. Crops are harvested from July to December. Yields of *jhum* rice (local) range from 2.5–3.0 t/ha compared with national yields in the same season of high-yielding varieties range from 3.5–4.0 t/ha (DAE, 2017).

Upland monocrop production includes ginger, turmeric, Different kinds of taro (aroid), cassava and different spices.

Floodplain and valley land rainfed rice-based farming mainly use high yielding or hybrid rice varieties with yields ranging from 4.7–6.50 t/ha (AD-DAE, 2017).

Vegetable-based farming for the household consumption or commercial production includes off-season vegetables (gourd, chilli, eggplant, beans, etc.) in upland fallow in summer, and cabbage, cauliflower and tomato in lowlands in winter.

Horticulture-based farming systems in sloping landscapes include banana, mango, lychee, pineapple, jackfruit, guava, olive, malta oranges, and bay leaf, which are grown commercially or for domestic consumption.

Cash-crop-based cultivation includes sugarcane (mainly the chewing variety), cotton and tobacco.

9.3.3.2 Forest and livelihoods

Hill people consider the forests as common property; they collect bamboo, timber, fuelwood and forage for food, roots, vegetables and herbs. Hunting, fishing and bird trapping for consumption are common activities. Due to population pressure, CHT communities have been compelled to alter their attitude to forest resources and their livelihood. Nowadays, much modern foraging

is due to economic hardship. So hill people still extract timber, bamboo, fuelwood and other forest products and these are sold to earn cash to support themselves.

9.3.3.3 Animal husbandry

Livestock production in the CHT is primarily for home consumption. The hill people consider livestock production secondary to their cropping activities. The livestock population comprises relatively small numbers of cattle, buffalo, goats, pigs, poultry and ducks. The local Chittagong Red cattle is not a recognized breed but provides one calf every year and an average milk production of 4–5 per cow per day. Pigs are the most important livestock for local communities. Most animals graze freely, with adequate green grass available year-round, except during the dry season (February to April). At this time, animals suffer from a shortage of food and water. Supplementary stall-feeding is needed to maintain normal animal health. Animals and birds suffer from different diseases due to the inadequate supply of preventive vaccines and lack of awareness of farmers. At present, numerous farms – including milk production cattle (278), goat (164), sheep (8), poultry (636) and duck (18) – are commercially operated in the private sector in CHT (DLS, 2012). CHTDF runs a community-based livestock improvement programme to de-worm and vaccinate cattle and poultry in collaboration with the DLS.

9.3.3.4 Fisheries

Kaptailake is the main water body of water in the region for fish culture, and covers around 68 300 ha in the monsoon and 58 000 ha in the dry season. Average fish production in the lake is 130 kg/ha, which is far below its potential.

9.3.3.5 Rubber plantations

Rubber plantations operate in both the public and private sectors. Rubber plantations started under an initiative of the CHT Development Board.

Table 9.14 Livestock and poultry population in the CHT in Bangladesh

Animal/bird	Rangamati	Khagrachhari	Bandarban	CHT total
Cow	184 654	134 814	170 927	490 395
Goat	142 457	109 211	63 623	315 291
Sheep	2 897	3 349	740	6 986
Buffalo	11 470	2 890	1 517	15 877
Pig	74 028	37 110	43 195	154 333
Chicken	483 994	851 344	297 234	1 632 572
Duck	112 837	69 843	51 520	234 200

Source: DLS, CHT districts, 2012

9.3.4 Animal production and grazing systems in mountain areas

Grassland is invariably intermixed with scrubland in the CHT and refers to the grass and scrub growth that takes over areas abandoned by *jhumias*. Its composition can include trees, scrub and grasses that are intermixed and unable to be mapped individually. The predominant grass is sunngrass (*Imperata arundinacea*), several types of shrub, and weeds such as Assam lota (*Eupatorium odoratum*).

9.3.5 Crops commonly grown in mountain areas

Valleys and plains: Rice (HYV and hybrid), potato, vegetables such as cabbage, cauliflower, bean, brinjal, cucumber, and different types of gourd.

Highlands: *Jhum* is the main cropping season where *jhum* rice, local *jhum* vegetables, taro, ginger, turmeric and bay leaf are grown. Horticultural crops such as mango, jack fruit, papaya, banana, pineapple, orange and malta oranges are also grown.

9.3.6 Income: Mountainous areas vs nation as a whole

Labour is the most important and often productive asset that CHT people have. Household income in the CHT is derived from agricultural products such as banana, seasonal fruits, *jhum* products, fishing from the Kaptai lake, backyard poultry etc. and limited number of services, industrial employment; agricultural labour; Fishing (again, mainly from Kaptai lake); animal farming (cattle, pig etc.); trade; traditional activities such as weaving; bamboo and cane work; the collection of fire wood; hunting etc.

Nationally in Bangladesh sources of income are derived from agricultural wages, industrial employment, services, construction, and small scale enterprises.

9.3.7 Livelihood practices

Certain livelihood activities are common nationwide, and some are more typical of the CHT district. Specific activities are those which stem from geophysical specialities of the region, conditioned by its unique systems, opportunities and cultural practices of the communities. Of the agriculture-related activities, some people work independently as owners/farm managers while others are lessees, sharecroppers or wage labourers. Others are self-employed in traditional activities, living for instance off the exploitation of natural resources (collecting firewood) or make a living with skills-based activities (weaving, furniture making, handicrafts, house construction, etc.). Agriculture is the predominant source of livelihood, particularly for ethnic communities. In the CHT, 49 percent of households live off agriculture (HDRC, 2009) compared to 46 percent in rural Bangladesh generally. (BBS, 2011). The reliance on agricultural livelihood is more dominant among the Tanchangya (72 percent), Khumi (69 percent), Marma (68 percent), Mro and Bawm (67 percent each). Business activities are more prevalent among the Pankhua and Lushai (30 percent each). Wage earners (non-farm wages and salaries) are more concentrated among the Chak and the Bangalee. The Khyang, Mro and Tripura are more engaged in traditional activities.

Case study

Fruit production is one of the great success stories of CHT with a production trend from 2003–2018. Before 2001, fruit production in CHT was poor with infestations of pests and sour fruit disorders as local varieties were grown.

Table 9.15 Distribution of population by livelihood source in the CHT in Bangladesh

Livelihood source	Percentage of annual net income													
	All SEC	Bawm	Chak	Chakma	Khyang	Khumi	Lushai	Marma	Mro	Pankhua	Tanchangya	Tripura	Bangalee	All CHT
Agriculture related	62.9	66.6	56.1	56.9	62.2	68.9	60.5	68.2	67.0	62.9	71.9	66.3	49.0	56.0
Business	8.1	10.0	7.8	9.6	7.6	2.6	29.6	6.1	7.1	29.9	6.5	2.1	18.4	13.1
Wages (non-farm)	9.5	9.4	29	10.1	0.0	2.5	0.0	10.8	2.3	7.2	7.1	9.7	20.1	14.6
Traditional	11.8	11.4	7.2	11.3	25.8	0.0	9.8	9.6	22.5	0.0	8.5	17.6	4.8	8.4
Others	7.9	2.6	0.0	12.0	4.4	26.0	0.0	5.3	1.1	0.0	6.0	4.3	7.6	7.8
Total	100	100	100	100	100	100	100	100	100	100	100	100	100	100

Source: HDRC, 2009

Since 2003, the adoption of high yielding varieties (Ambrapali, Ranguyai, China-2, China-3, Bari Malta-1), improved fertilizer application, and proper pest and disease management produced a huge increase in yield. Current fruit production (of mango, lychess, malta, jackfruit, and lemon) is about 475 182 MT. If pineapple and banana production is included, this figure increases to more than 600 000 MT (DAE, 2018).

9.3.8 Institutions related to mountain agriculture development in the CHT

The following departments of the Government of Bangladesh have been working in CHT for agricultural development:

- ◆ Department of Agricultural Extension (DAE)
- ◆ Horticulture Centre
- ◆ Agricultural information Service
- ◆ Agricultural Training Institute (ATI)
- ◆ Department of Livestock Services (DLS)
- ◆ Department of Fisheries (DoF)
- ◆ Bangladesh Agricultural Development Corporation (BADC)
- ◆ Department of Forests
- ◆ Bangladesh Agricultural Research Institute (BARI)
- ◆ Bangladesh Livestock Research Institute (BLRI)
- ◆ Bangladesh Fisheries Research Institute (BFRI)
- ◆ Bangladesh Fisheries Development Corporation (BFDC)

- ◆ Soil Resource Development Institute (SRDI)
- ◆ Bangladesh Sugarcane Research Institute (BSRI)
- ◆ Bangladesh Sericulture Board (BSB)

9.3.8.1 Private sector

The private sector is expanding in almost all spheres. They are contributing to production (agriculture, agroprocessing) and services (sale of seed, fertilizers, pesticides, tools and implements, marketing and value chain management). Each hill district has a Chamber of Commerce and Industries with individual membership.

9.3.8.2 NGOs

NGOs are active in all the hill districts. There are reportedly 17 national NGOs who have activities in the CHT. In addition, 267 local NGOs are registered with different authorities. Not all of them are functional. Some of them have programmes for agricultural development. Local NGOs so far helped in setting up community based organizations (CBOs) at the para (village) level including 690 Farmers' Field Schools (FFS), 3257 Para Development Committees (PDC) and 1685 Para Nari Development Groups (PNDG) within the framework of the CHTDF. Presently CHTDF has 13 NGO partners under its Community Empowerment Project (CEP).

9.3.9 The challenges of hill and mountain agriculture in the CHT

A Crop related

a Seeds and planting materials

Seeds and planting materials are preserved by farmers to meet their own needs. Sometimes farmers collect such materials from neighbouring farmers.

Although some private companies and BADC are the main sources of improved or hybrid seeds and have extended their market up to the big bazaar level, many farmers are not aware of the quality of seeds and saplings and sometimes are risk poor yields when they go for production with bad or adulterated seeds and saplings.

b Agro-chemicals

Farmers buy agro-chemicals like fertilizers and pesticides from retail shops, dealers and wholesalers. But these outlets are not easily accessible in remote areas. For application and dose of fertilizers and pesticides, farmers usually depend on the “advice” of the sellers. In most cases they are not aware of the quality of chemicals. DAE extension staff are not available for consultation in many places.

c Household food and seed storage

Farmers store food and seed generally for three major objectives, (1) food for future consumption before the next harvest, (2) seed for next sowing/ plantation season and (3) sale at a better price. Most farmers face problem when it comes to storing and marketing their products. Major problems are the lack of space for storage at the household level, the absence of storage facilities for perishable commodities and different microbial spoilage of the produce, which compels farmers to sell their products immediately after the harvest and at a very low price. Poor farmers are sometimes forced to sell their seeds before the next sowing season.

d Transportation and packaging

Depending on the location of the village and the bazaar, farmers have to travel anywhere between 0–25km to sell their produce, with most farmers reporting a distance of 5km to the local market and average distance to the major township market reported at 20km. Farmers in remote areas find it difficult or almost impossible to market their products, as they have to carry their produce by hand.

e Jhum cultivation

The main problem of *jhum* cultivation system is poor productivity. The seeds are not of improved variety and their yield potentiality is not high. Moreover the farmers do not follow different improved management practices like weeding, fertilizing, pest management etc. This often means that *jhum* farmers don't enjoy good harvests. The scarcity of land is another problem of *jhum* production. During *jhum* hill preparation, burning destroys many living organisms as well as herb and shrubs, greatly affecting the biodiversity of growing areas.

In addition, if farmers use spades for cultivation then it can cause soil erosion during rainy season.

f Soil fertility

Soil is the main supplier of plant nutrients. The soil of the CHT is less fertile when compared to other parts of Bangladesh because it mostly originates from the weathering and erosion of bedrock. Moreover, the soils formed over unconsolidated sedimentary rocks containing significant amount of kaolinite clay, which provides a low capacity to retain nutrients.

g Fringe land

In the dry season vast agriculturally potential lands rise up where the people produce rice, different vegetables etc. This land is called fringe land. The rule curve helps farmers produce crops in this fringe land. But every year the farmers are not sure whether the fringe land will rise up or not. So there is an uncertainty when it comes to production. Due to problem of irrigation facility and some other management practices, the production of the fringe land crops is not satisfactory. Water hyacinth is another problem of Kaptai Lake for navigation, as there is no activity to check its spread.

h Irrigation and watershed conservation management

Most of the crops in CHT are cultivated using rainfed methods. Sometimes supplementary irrigation is needed for valley rice cultivation. The winter valley crops (rice or vegetables) are cultivated with irrigation. For better yields in valley crops (either paddy or any other crops) irrigation plays a vital role during the winter season. In winter, water sources include dams, streams, springs, using low lift pumps (LLP) or gravitational flow of hill water. *Jhum* cultivation methods however are fully depends on rain water or rainfed conditions. In the hilly crop cultivation (mixed or solo fruit production, spices etc.) water scarcity is a major problem especially during the months from October to March. In many places there is no facilities such as irrigation channels or water source for irrigation.

i Harvest and post-harvest management

There is no improved method of fruits harvest or collection. Most of the fruits are collected directly as they drop from the trees. This causes issues with quality. Some fruits and vegetables are perishable and need to be marketed to consumers as early as possible after harvest. As most fruits and vegetables are made available to market within a limited period, this causes a glut of produce during the peak harvesting time, and this affects prices.

Various marketing limitations exist. These include a lack of farmers or growers associations or cooperatives, limited volume of produce due to small farm sizes, seasonal production, immediate need of cost returns, inadequate and underdeveloped transport systems, high charges in the form of local tax and tolls, lack of facilities like roads, water and communication infrastructure, poor market channels, a lack of market information, absence of storage and processing facilities, government interventions etc. Moreover middlemen dominate the marketing systems. (Talukder and Paul, 2013).

j Collection mechanisms

Farmers often transport their produce from their farms in one move or piecemeal based on product type, day and proximity to nearest bazaar or the market place. Other factors include the maturity status of a harvest, and requirements for cleaning, sorting, grading and drying. Farmers usually sell their produce direct from the farm site or at the local bazaar. In some cases, middleman or the whole-sellers (*paiker*) purchase from farmers at farms site or the local bazaar at local market rates. In some cases, before loading for the bigger bazaars, commodities are stockpiled by roadsides or in other open places, as such venues offer big spaces, storage sheds and parking spaces that are mostly absent in local bazaars. However, the collection process can be prolonged if collection points are located in remote places.

k Horticultural crops

In some areas of the CHT there is a problem of availability of quality seed or seedlings for horticulture crops. This is in addition to other problems regarding horticultural production in the CHT such as lack of manpower and budget allocation etc. Many farmers are not aware of the many improved agricultural management techniques in horticulture and poor irrigation causes other issues. Poor communication systems are another major problem for increasing horticultural garden.

l Market infrastructure

Bazaars or growth centres are the usual places where commodity transactions (buying and selling) between farmers, retail traders and wholesalers takes place. As in other parts of the country, Local Government or Local Government Engineering Departments (LGED) have developed growth centres with some infrastructure, such as sheds for retailers and wholesalers as well as tube wells, toilets, internal roads, approach roads, etc. (though not all such centres have these facilities). Generally, these centres

are leased to private parties. These leaseholders are more concerned about collecting tolls than providing services to traders and customers and this not only causes friction, but means that producers' needs are not met.

m Deforestation

New settlements are developing in deep forest areas. For livelihood subsistence, people often forage in the forests and cut down valuable trees beyond the knowledge of the Forest Department. This has led to some areas becoming barren and deforested. The effect of this is that *chharas* (hill streams) and other water sources in the hills dry up within a few years and this affects field crop irrigation and sustainable crop production. Reforestation is possible but only with native trees. It is believed that timber trees such as teak, rubber and eucalyptus are not eco-friendly and are more likely to cause natural hazards.

n Tobacco

The production of tobacco causes problems as there is a large element of environmental degradation involved in tobacco cultivation. Tobacco plants deplete more soil nutrients than other crops and as wood from forests is used for drying and curing tobacco, can exacerbate deforestation. However, farming tobacco is attractive to many farmers as tobacco companies provide loans and incentives to grow the crop.

o Agroprocessing and Value Chain Development

Agroprocessing storage facilities for perishable commodities do not exist in this region. Modern facilities with high overhead costs may not be feasible, as they need high investment, guaranteed access to electricity and a good road network. Due to poor infrastructure, transport costs remain high and prices are adjusted at different points by the wholesalers who fix low prices to maintain the competitiveness of similar products from elsewhere. The cumulative effect of this phenomenon is very low prices for producers who are the primary point in the value chain. Also, simple, home-based technology for storing and processing many commodities is absent. While certain processing activities, such as pickling mango and drying vegetables, is carried out at the household level, this mainly for home consumption. CHT is yet to have large-scale agroprocessing plants or any effective mechanisms to procure local products through collection centres, as can be found in other parts of the country (e.g. Milk Vita, Pran, Aarong) which boast established supply networks among poor and small farmers in many districts.

B Livestock related**a Fodder crop/feed /grazing land**

Cow, pig, goat, poultry and buffalo are common and important animals for farmers. Most of the animals are left to open graze, moving here and there for their food. In summer and during the rainy season, there is plenty of fodder but it can be scarce in the dry season.

b Deworming programmes

The main reason for malnutrition and ill health in animals is the infestation of different types of worms. Many farmers are not aware of new and effective deworming practices.

c Vaccination

There are some problems with vaccination activities due to the inadequate supply, poor communication facilities and lack of knowledge on how to store the vaccines. As such, livestock health is often poor. In some *upazilas*, issues with electricity supply can cause problems with the storage of vaccines/medicines.

d Veterinary health services

Most of the technical posts like Upazila Livestock Officer (ULO), Veterinary Surgeon (VS) or field workers are vacant in many *upazilas*, which causes major problems for veterinary health services. There is also no disease diagnosis laboratory in the district. The supply of different medicines is not adequate to fulfill demand.

e Quality breeds

Most of the livestock in the region are local, not improved breeds, and this means that the productivity of meat, eggs, and milk is not high. Moreover, farmers are not aware of quality breeds and many are not interested in the AI programme for breed development in cattle. Poor communication is a problem for field workers.

C Fisheries related**a Scarcity of ponds/water bodies**

The largest water source in the district is Kaptai Lake, with most other ponds and water streams in the district being seasonal. As this is a hilly area, there is a lack of water bodies/ponds for fish culture. Fish farmers often do not take care of existing ponds or follow proper management guidelines for improved fish culture. The BFDC does not permit pen/cage culture in the lake area.

b Quality fingerlings/fish feed

The availability of quality fingerlings in the district is a problem. The only government hatchery in CHT is in Kowkhaliupazila. There is no nursery at the *upazila* level. Most of the fingerlings are collected by farmers from outside the district. As a result, the price of fingerlings is high, and the quality is questionable. The availability of fish feed is another problem for fish farmers, with no authorized dealer in CHT. Knowledge of fish feed preparation is unknown to most, which reduces fish productivity.

D Population pressure and degradation of natural resources

Due to increasing population pressure, hilly land in general is not being cultivated according to the scientific method. Some land has been ploughed without considering adequate conservation measures. This has led to the degradation of natural resources. In hills, agriculture development is constrained by the lack of appropriate technology, inadequate infrastructure, poor input–output marketing, insufficient extension education and networks. There has also been a decrease in area for forest dwellers and diversity of farming system or land use type. Traditional agriculture combining crop production with livestock, horticulture or agroforestry is practiced. Inaccessibility, fragility, marginality, heterogeneity, natural instability, and human adaptation mechanisms have been identified as key factors for the lack of sustainable agricultural development in hills.

The working age population (15–59) is estimated to make up 45 percent of the total population in Bangladesh (BBS, 2007). This means that more than 8 600 new jobs need to be created each year on average to absorb the incremental workforce in CHT up to 2051. Up to 2021, the average annual demand for new jobs will be around 11 000, of which more than 800 will be in rural areas. This is a big challenge. An increase in population will reduce per capita availability of land, while increasing the demand for food, water, housing, energy and recreational facilities. With the increasing population and declining land resources, access to food will be constrained, resulting in further food insecurity and malnutrition. With increasing urbanization and demand for infrastructure, agricultural land will shift to other land uses, which will increase the pressure on the natural resource base, with the added risk of further degradation of land and water quality. With increasing social mobility, particularly of women, and the increased adult population, the supply of labour force and consequently demand for jobs will increase.

E Capital /agricultural credit

Successful and commercial livestock farming (dairy, pig, poultry or other) needs capital investment. Most farmers in CHT are not solvent for commercial farming. Moreover, the livestock loan process often used in commercial farming requires documentation which is often not available to local farmers.

9.4 Opportunities and entry points for mountain agriculture development to address Zero Hunger and poverty reduction

9.4.1 CHT: Potential and opportunities

- ◆ Kaptai Lake is the biggest man-made lake in south-east Asia (with a surface area of around 68 000 ha in the monsoon season and 58 000 ha in the dry season)
- ◆ Agro-industry (horticulture, agroforestry, farm forestry, bamboo, coffee, cashew nut, citrus fruit, medicinal plant, organic products)
- ◆ Rich in forests, biodiversity, non-timber forest products
- ◆ Non-agriculture sector includes tourism, handicrafts, wood industry, cultural services, value chain
- ◆ Agro-based micro-enterprises
- ◆ Labour mobility
- ◆ Fishery and aquaculture
- ◆ Livestock sector

9.4.1.1 Measures and initiatives taken in mountain agriculture development

Chattogram Hill Tracts Development Board (CHTDB) initiatives. There are a great many initiatives being made in the CHT backed by investment. The CHTDB has implemented 382 projects in the road communication sector in the last five years, at a cost of USD 31.16 million. Under the Integrated Community Development Project (ICDP), the CHTDB has established 4 000 Para Centres (Village Centres) across the CHT region in the last four decades to provide pre-primary education and improve the health and nutrition status of children and women from 160 000 families. The CHTDB has spent USD 1.88 million constructing irrigation canals, dams, and sluice gates to increase agricultural productivity. Under its long-term projects, the CHTDB has assisted 6 955 families to rehabilitate 13 000 acres of rubber

plantations, establish 7 700 acres of mixed fruit orchards on hill slopes and 155 dairy farms, and has distributed 2 50 000 rubber saplings across CHT, at a cost of USD 11.69 million. In the last few years, more than 1 500 acres of orange and mixed fruit orchards have been established. The CHTDB has supplied solar energy to 5 890 households and 2 814 community centres/schools and orphanages that were not on the National Grid, at a cost of USD5.00 million. With a view to empowering women, the CHTDB has implemented a project called “Rearing of Cows for better Income” to generate opportunities for marginal and poor women in remote areas of CHT. This project will distribute cows to 1 300 village women and has provision for proper training, vaccines, fodder plots, worming, sheds and biogas, at a cost of USD 1.60 million. The CHTDB also has some initiatives for harvesting rainwater and building small dams and water-points to ensure a constant water supply. As part of this initiative, the CHTDB has launched many agro-based programmes with the dual objective of reducing rural poverty and conserving nature.

The CHTDB recently launched a project titled “Production of Quality Bamboo for Livelihood Support of Backward Communities in CHT” to establish 1 300 bamboo gardens in the hilly region, at a cost of USD 2.97 million. The CHTDB has also implemented a project titled “Sustainable Social Services in the Chittagong Hill Tracts (SSSCHT)” with support from UNICEF, at a cost of USD 51.16 million. The CHTDB has also set up a germplasm centre for rare plant species in Khagrachari. As a result of these many successful initiatives, the CHTDB received an Honourable Mention in the ICIMOD Mountain Prize 2018 for outstanding socio-economic infrastructure development of CHT.

FAO’s engagement and initiatives in CHT. From 2013–2016, FAO implemented several projects related to food and livelihood security, nutrition, agricultural development, environmental sustainability, emergency food and cash intervention, input delivery in rural areas, poultry production, and traditional cultivation systems. The following projects have been jointly implemented by MoA, MoCHTA and FAO with a view to promoting mountain agriculture in Bangladesh:

- ◆ Food Security through Enhanced Agricultural Production Diversified Sources of Income, Value Addition and Marketing in Bangladesh.
- ◆ Rain water harvesting in hilly creeks/charas to restore sustainable Agriculture-Based Livelihoods in Hilly areas of the CHT.

- ◆ Emergency assistance to support the recovery of crop-based livelihood systems of marginal farmers affected by communal violence and loss of agricultural capital in Taidong union, Khagrachari District, CHT.
- ◆ Support to Rural Livelihoods and Climate Change Adaptation in the Himalayas (Himalica) at the Chittagong Hill Tracts, implemented by the Arannayk Foundation (AF) in collaboration with ICIMOD
- ◆ Strengthening Inclusive Development in Chittagong Hill Tracts (SID-CHT) project implemented by UNDP.

9.4.1.2 Main achievements since 2003:

- ◆ 132 schools across CHT provide education for nearly 7 000 indigenous children in their native languages.
- ◆ More than 20 000 children each year have improved conditions for education in 315 newly constructed or renovated primary schools.
- ◆ 16 mobile medical teams and 80 weekly satellite clinics have been established throughout the CHT.
- ◆ 1 729 rice-banks established to enable over 50 000 household to borrow rice and overcome food shortages.
- ◆ 1 633 FFS have been established to teach farmers new techniques for improving agriculture production and increasing income.
- ◆ 55 Village Common Forests (VCFs), or Mouza Reserves, are supported to protect biodiversity, improve livelihood and strengthen participatory forest management.
- ◆ 3 507 Para Development Committee (PDC)s have been trained, linked with banks and government line departments, and supported to manage and implement community development projects benefiting over 115 000 households.

Legislation, Policies and Institutions in the CHT Region

- ◆ CHT Manual 1900
- ◆ CHT Land Acquisition Regulation 1958
- ◆ Hill District Local Government Council Act 1989
- ◆ CHT Peace Treaty 1997
- ◆ CHT Regional Council Act 1998
- ◆ Perspective Plan of Bangladesh 2010–2021
- ◆ CHDB Law 2014
- ◆ Seventh Five Year Plan 2016–2020

Policies

- ◆ National Forest Policy
- ◆ National Environmental Policy
- ◆ National Water Policy
- ◆ National Industry Policy
- ◆ National Agriculture Policy
- ◆ National Tourism Policy

Strategies

The development of mountain agriculture in CHT for achieving Zero Hunger and poverty reduction includes the following integrated strategies:

- ◆ Improve livelihoods through sustainable adaptation and improved *jhum* practices.
- ◆ Improve livelihoods in the CHT through sustainable agricultural production.
- ◆ Improve livelihoods through awareness of food security and nutrition in the CHT.
- ◆ Create livelihood opportunities through homestead agroprocessing, value chain and marketing systems.
- ◆ Enhance agricultural productivity based on sustainable management of natural resources.
- ◆ Up-scale input supplies in the CHT.
- ◆ Develop the farm sector (agriculture, horticulture, agroforestry, fisheries, and livestock) as the key to reducing poverty and achieving food and nutrition security.
- ◆ Develop the non-farm sector (tourism, cultural services, labour mobility, migration, remittance, micro-enterprises) to accelerate economic growth and reduce poverty and vulnerability.

Action plans and frameworks

Sustainable agriculture development in the mountains can be supported by enabling policy and institutional reforms, ensuring tenurial security, generating integrated demand driven technology and service delivery, enhancing access to production assets and resources, credits and markets, and capacity building of farmers with strategic considerations of mountain specificities, biophysical and socio-economic conditions and livelihood options of mountain people. There is a need to generate employment in agriculture by promoting niche commodities, organic farming, processing and value addition, and non-farm and off-farm employment (Rasul and Kollmair YEAR).

The Ministry of Chittagong Hill Tracts Affairs (MOCHTA) is responsible for the planning, implementation, and monitoring of development programmes and projects in the CHT. However, the sectoral approach of line ministries and fragmented work of different non-governmental organizations often leads to overlap and fails to produce the desired development outcomes. To ensure that development activities are more effective and sustainable, and to avoid duplication, MOCHTA should be entrusted with the full responsibility of coordinating development work in CHT (Rasul, 2015).

Strategies and Action Plans are needed to achieve Zero Hunger and Poverty Reduction in CHT, including:

Crop related plans

- ◆ Improve *jhum* cultivation by ensuring sustainable *jhum* cultivation, providing drought-tolerant, quality seeds, introducing Integrated Pest Management (IPM) and transforming *jhum* agroforestry, horticulture, animal husbandry, and other more productive systems.
- ◆ Improve irrigation facilities and sustainable watershed and spring shed management along with the restoration of watersheds.
- ◆ Post-harvest management for reducing post-harvest loss.
- ◆ Better use of fringe land for diversified crop production.
- ◆ Increase horticultural crop production through the extension of mixed orchards and improved management practices.
- ◆ Soil conservation using sustainable technology, selecting crops addressing crop intensity and hill surface covering.
- ◆ Ensure the availability of quality seed and fertilizer.
- ◆ Afforestation.
- ◆ Market promotion of agricultural products.
- ◆ Develop road and water way communication.
- ◆ Provide real-time market information system.
- ◆ Strengthen market linkages and develop value chain.
- ◆ Introduce floating agriculture in Kaptai Lake.
- ◆ Invest in agro-processing.
- ◆ Improve input management.
- ◆ Introduce modern farm machinery and tools for better production.
- ◆ Improve agricultural R&D support.
- ◆ Increase Human Resource support.

Livestock related plans

- ◆ Increase quality breed and feed availability by conducting efficient Artificial Insemination (AI), workshops backed by regular training and motivation.
- ◆ Provide animal health care through regular vaccination and worming programmes.
- ◆ Develop and establish livestock farms for cattle, goats, sheep, pigs, duck and other poultry, etc.).

Fisheries related plans

- ◆ Encourage sustainable management of Kaptai Lake by increasing the number of sanctuaries, fish production, pan/cage culture, stocking size, duck rearing, etc.
- ◆ Develop/repair new/existing ponds, creeks.
- ◆ Increase quality fingerlings/fish feed.
- ◆ Expand creek aquaculture.
- ◆ Improve the environmental quality of Kaptai Lake.

Credit facility

- ◆ Motivation activity.
- ◆ Coordination.
- ◆ Ensure hassle-free service.

Other interventions

- ◆ Establish germplasm centres.
- ◆ Establish herbal gardens.
- ◆ Increase sugarcane production.
- ◆ Replace tobacco cultivation with other cash crops.
- ◆ Increase mushroom production.
- ◆ Provide ICT facilities at the community level for better service and needs-based information.
- ◆ Increase pulse and oilseed production.
- ◆ Increase cotton production.
- ◆ Promote off-farm activities.
- ◆ Extend tea plantations.
- ◆ Extend sericulture by supplying silkworm eggs/larvae and mulberry seedlings and providing management practices.
- ◆ Engage the private sector in marketing and skills development.
- ◆ Disseminate technology at the grass roots level and improve management systems, including planning, implementation, monitoring, evaluation, agricultural credit flow, and follow up extension activities.

Table 9.16 List of Future Smart Food in the CHT in Bangladesh

Name of Future Smart Food (local name)	Category/classification 1) non-timber product; 2) minor crops; 3) main medicinal plants-pls select	Type of crops (e.g. cereal; tubes, roots; vegetable; fruits, etc)	Nutrients	Altitude (range)	Latitude (range)	Longitude (range)	Soil type	Min temperature (average)	Maximum temperature (average)	Rainfall	Crop grown period
1 Foxtail millet	2	Cereal	Protein, carbohydrates and fat	0-300 m			Sandy loam	12°C	35°C	400-3 000 mm	APR-SEP
2 Yam	2	Root	Calories, Sodium, Potassium, Carbohydrate and Protein	0-300 m			Sandy-loamy, clay soil	12°C	35°C		MAR-SEP
3 Taro (Mukhi kachu and panikachu)	2	Root	Protein and fat	0-50 m			Do	12°C	35°C		Do
4 Giant taro (Man kachu)	2	Root	Protein and fat	0-500 m			Do	12°C	35°C		Do
5 Elephant foot yam (Ol kachu)	2	Root	Potassium, Phosphorous and Magnesium	0-500 m			Do	12°C	35°C		Do
6 Sweet potato	2	Root	Vitamin A	0-100 m			Sandy-loamy, clay soil	12°C	35°C		SEP-MAY
7 Cassava	2	Root	Calories and carbohydrate	0-100 m			Sandy-loamy	12°C	35°C		MAR-SEP
8 Aroids (Moulavikachu, dudhkachu, dastarikachu)	2	Root	Calories, protein, fat, iron, fiber, calcium, phosphorous, carbohydrates and vitamin	0-50 m				12°C	35°C		Do
9 Lentil	2	Tubes	Protein	0-30 m			Sandy loam	12°C	35°C		OCT-MAR

Source: DAE, Rangamati 2019

Table 9.16 List of Future Smart Food in the CHT in Bangladesh (*continued*)

Name of Future Smart Food (local name)	Category/classification 1) non-timber product; 2) minor crops; 3) main medicinal plants-pls select	Type of crops (e.g. cereal; tubers, roots; vegetable; fruits, etc)	Nutrients	Altitude (range)	Latitude (range)	Longitude (range)	Soil type	Min temperature (average)	Maximum temperature (average)	Rainfall	Crop grown period
10 Pigeon pea	2	Pulse	Vitamin				Sandy clay loam soil	21°C	28°C		APR–SEP
11 Field pea		Pulse	Vitamin								
12 Groundnut	2	Oil	Carbohydrate, Protein and fat				Sandy clay loam soil	12°C	30°C		
13 Snake gourd	2	Vegetable	Calcium, Iron, Carotene and Vitamin C				Sandy clay loam soil	12°C	35°C		Year round
14 Amaranth	2	Vegetable	Manganese, magnesium, phosphorus and iron				Sandy loamy	12°C	35°C		
15 Yard long bean	2	Vegetable	Iron, copper, manganese, calcium and magnesium				Do	12°C	35°C		
16 French bean	2	Vegetable	Folate, thiamin, riboflavin, iron, magnesium, and potassium				Do	12°C	35°C		
17 Ash gourd	2	Vegetable	Vitamin B1, Vitamin B3 and Vitamin C				Do	12°C	35°C		

Source: DAE, Rangamati 2019

Table 9.16 List of Future Smart Food in the CHT in Bangladesh (*continued*)

Name of Future Smart Food (local name)	Category/classification 1) non-timber product; 2) minor crops; 3) main medicinal plants-pls select	Type of crops (e.g. cereal; tubes, roots; vegetable; fruits, etc)	Nutrients	Altitude (range)	Latitude (range)	Longitude (range)	Soil type	Min temperature (average)	Maximum temperature (average)	Rainfall	Crop grown period
18 Ridge gourd	2	Vegetable	Vitamin C, zinc, iron, riboflavin, magnesium and thiamine				Do	12°C	35°C		
19 Okra	2	Vegetable	Calories, sodium and carbohydrates				Do	12°C	35°C		
20 Pumpkin	2	Vegetable	Vitamin A, Potassium, Copper and Manganese				Do	12°C	35°C		
21 Bitter gourd	2	Vegetable	Calories, Potassium and Zinc				Do	12°C	35°C		
22 Custard apple	2	Fruit	Potassium and magnesium				Do	12°C	35°C		
23 Wood apple	2	Fruit	Vitamins, calcium, phosphorous, protein and iron				Do	12°C	35°C		
24 Sapota (Sapodilla)	2	Fruit	Vitamins, minerals, glucose, tannins and calories				Do	12°C	35°C		
25 Black cumin	2	Spice	Protein, vitamins and fatty acids				Any soil appropriate PH balance	12°C	35°C		
26 Coriander	2	Spice	Vitamin C				Sandy clay loamy	12°C	30°C		
27 Ajowan											

Source: DAE, Rangamati 2019

Table 9.16 List of Future Smart Food in the CHT in Bangladesh (*continued*)

Name of Future Smart Food (local name)	Category/classification 1) non-timber product; 2) minor crops; 3) main medicinal plants-pls select	Type of crops (e.g. cereal; tubers, roots; vegetable; fruits, etc)	Nutrients	Altitude (range)	Latitude (range)	Longitude (range)	Soil type	Min temperature (average)	Maximum temperature (average)	Rainfall	Crop grown period
28 Onion	2	Spice	Vitamin C, dietary fiber and folic acid				Sandy clay loamy	12°C	35°C		
29 Radish	2	Spice	Vitamins A, B6, C, E and K				Do	12°C	35°C		
30 Turmeric	2	Spice	betacarotene, ascorbic acid (vitamin C), calcium, flavonoids, fiber, iron, niacin, potassium and zinc				Sandy loam	12°C	35°C		
31 Garlic	2	Spice	Calcium, copper, potassium, phosphorus, iron and vitamin B1				Do	12°C	35°C		

Source: DAE, Rangamati 2019

9.5 Strategic consideration and suggestion

The following recommendations are vital to implement at the national and regional level to contribute to sustainable agriculture development:

Policy, socio-economic and Institutional considerations:

- ◆ Resolve land disputes to reduce social conflicts and improve investment status, and agricultural productivity; ensure customary land rights and establish peace and stability;
- ◆ Increase attention to risk management and develop policies for prevention, mitigation and relief to cope with natural disasters;
- ◆ Establish new financial institutions (CHT Bank) to provide loan-credit with soft condition to the mountain farmers and entrepreneurs;
- ◆ Involve representatives of mountain communities in decision-making and implementation processes of policies and in initiatives taken to support mountain agricultural development;
- ◆ Increase the resilience of mountain farmers and small agroindustrial enterprisers by linking them with markets, and providing subsidies for added values to mountain products especially Future Smart Food (FSF) and other non-food products, to diversify income of mountain communities particularly women;
- ◆ Implement the Inclusive Budgeting and Financing for Climate Resilience (IBFCR) for Technical Assistant Project (Finance Division of GoB);
- ◆ Promote conservation agriculture in *jhum* farming;
- ◆ Implement the Bangladesh Climate Change Strategy and Action Plan (BCCSAP), 2009 in the CHT;
- ◆ Allocate funds from Bangladesh Climate Change Resilience Fund (BCCRF) for climate change resilience issues;
- ◆ Implement the National Biodiversity Strategy and Action Plan to protect and revive biodiversity in the CHT;

- ◆ Increase government support for local community groups and co-operatives to develop non-farm enterprises focused on processing, packaging, and branding of farm-based produce; production of handicrafts from local resources; and service delivery;
- ◆ Promote agro-based micro-enterprises;
- ◆ Promote agroforestry with mixed commercial productivity;
- ◆ Preserve forest, sanctuary, biodiversity and ecology;
- ◆ Prepare a National Adaptation Plan (NAP) in the CHT, and
- ◆ Ensure better coordination among relevant departments and institutions.
- ◆ Information Technology (IT)-based communications might be important for connecting mountain areas internally and externally. This has helped to link various mountain areas to mainstream economies.
- ◆ Implement MATH (Modern Agriculture Technology in the hills) as a suitable agricultural technology in the CHT to increase production.
- ◆ Increase capacity development for homestead-based agro-processing, training, agro-business.
- ◆ Increase capacity building programmes to encourage entrepreneurship in CHT communities.
- ◆ Organize awareness and capacity building programmes for nutrition.
- ◆ Start a capacity building programme for the use of quality indigenous breeds, ensuring scientific husbandry, and feed management.
- ◆ Initiate a programme for local adaptive research.
- ◆ Focus agricultural R&D on new technologies for marginal and sloping land.
- ◆ Support activities aimed at homestead-based production (crops, fruit, livestock, mushrooms, year-round vegetable cultivation).
- ◆ Improve productivity of creek aquaculture, awareness building on nutrition for women and children.
- ◆ Provide vocational training to eligible youth for better employment opportunities as a useful non-farm option to combat the problem of labour migration.

Resource management and environment conservation:

- ◆ Harvest rainwater by building check dams, and use other indigenous technologies that make better use of rainwater for productive purposes in irrigation, livestock, and other economic activities.
- ◆ Ensure community-led forest management by setting up joint management groups that empower the traditional institutions, build modern management capacity, and allow communities to develop their own resource management plans to address conservation and livelihood issues.
- ◆ Promote and restore watersheds/stream sheds/spring sheds through small-scale infrastructure programmes.
- ◆ Harness the full potential of Kaptai Lake resources.
- ◆ Include cultural and geographical aspects and indigenous knowledge and local skills in the design and development of water schemes.

Capacity development, research and technology:

- ◆ Make use of the opportunity that International Mountain Day on 11 December offers to organise events and workshops to promote sustainable development of mountain agriculture.
- ◆ Promote SALT (Sloping Agricultural Land Technology) in the CHT.
- ◆ Promote skills enhancement training for women.

Crop and livestock and integration:

- ◆ Provide technical assistance to establish mixed fruit orchards to increase the potential for greater remuneration and diversification of livelihoods.
- ◆ Promote integrated farming of fish–poultry, fish–cattle–poultry, and fish–livestock–agriculture.
- ◆ Promote sustainable mixed fruit gardens and high-value crops.
- ◆ Provide technical assistance for soil health and conservation in hill agro-ecologies.
- ◆ Promote beekeeping as an important livelihood and income generating option as the indigenous honeybee *apis cerana* is common in all three districts.

Infrastructure Development:

- ◆ Increase connectivity in the CHT and connect scattered rural areas so that the rural population can gain better access to markets, education and health facilities, and enjoy increased employment opportunities.
- ◆ Establish and create links for a proper marketing systems in the CHT.

The importance of the holistic management of land, water and vegetation resources in the watershed for improving livelihood and reducing risk, mainly from landslides and floods in the region, should be emphasized. Participants highlighted the need for management in the context of local knowledge and traditional systems rooted in the CHT, with effective coordination of development agencies working in the CHT involving traditional leaders and local communities. Numerous development agencies are currently working in the CHT and these agencies should coordinate a master plan for equitable, justified, rational and sustainable development in the CHT region.

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10 Bhutan

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10.1 Overview

10.1.1 About the country

10.1.1.1 Physical characteristics

Bhutan is a landlocked country sandwiched between India and China, located between 26° 45' N and 28° 10' N latitude and 88° 45' E and 92° 10' E longitude. The total land area is 38 394 km². The elevation ranges from 160 to 7 314 metres above sea level (masl), with the highest peak being Jhomo Lhari (NSB, 2017a).

Bhutan is known for its strict environmental conservation policies, with a mandate written into its constitution to maintain at least 60 percent forest coverage. Today, Bhutan has 71 percent forest coverage and 51 percent of its area falls under the Protected Area Networks and Biological Corridors (NSC, 2017a), making Bhutan a carbon-negative country. Bhutan's success with the conservation of natural resources, particularly forests, is to a certain extent fostered by tradition and social beliefs. MoAF (2008) recognizes that the conservative nature of the Bhutanese, fostered through "social beliefs such as *ridam* (literally 'locking the mountains' forbidding harvest of natural resources for certain periods in a year) and through customary rights", has preserved most of the watersheds. Further sustainability of the

environment comes from the Buddhist precept that "all life forms are sentient beings existing in a state of harmonious interdependence" (Dorji, 2004). The afforestation and reforestation programmes are mainstreamed into government programmes.

Given the extreme mountainous geography and terrain in Bhutan, agricultural land is limited with only 2.76 percent under cultivation. The land cover varies between regions and districts (MoAF, 2016). Bhutan is divided into six agro-ecological zones (AEZs), which are detailed in Table 10.1.

10.1.1.2 Demographics

Bhutan's small population of 747 125 people is spread across 20 districts. The population density is 19 people per km², making Bhutan one of the world's least populated countries. The average household size is 4.6 (NSB, 2017a).

There are more males in Bhutan (52.46 percent) than females (47.54 percent). Most people reside in rural areas (62.2 percent) while 37.8 percent are urban dwellers (NSB, 2017b).

Bhutan has a young demography with a median age of 26.9 years in 2017 (NSB, 2017b).

Table 10.1 Agro-ecological zones and agriculture production in Bhutan

Agro-ecological zones	Altitude range (masl)	Area (ha)	Area (%)	Major crops and livestock
Wet subtropical	100–600	214 918	5.60	Paddy pulses, tropical fruits, vegetables
Humid subtropical	600–1 200	392 700	10.23	
Dry subtropical	1 200–1 800	503 465	13.11	Maize, paddy cattle, pigs, poultry, vegetables
Warm temperate	1 800–2 600	714 554	18.61	Potatoes, temperate fruits, vegetables, yaks, cattle, sheep, horses
Cool temperate	2 600–3 600	917 155	23.89	
Alpine	3 600–7 500	1 096 618	28.56	Yaks, buckwheat
Total		3 839 409	100.00	

Source: MoAF, 2015

Table 10.2 Poverty outcomes during 2007, 2012 and 2017 in Bhutan

S. number	Districts	Poverty head count (%)		
		2007	2012	2017
1	Bumthang	10.93	3.44	2.1
2	Chhukha	20.27	11.25	3.5
3	Dagana	31.10	25.10	33.3
4	Gasa	4.15	0.00	12.6
5	Haa	13.19	6.39	0.9
6	Lhuentse	42.97	31.89	6.7
7	Mongar	44.41	10.54	17.1
8	Paro	3.95	0.00	0.3
9	Pema Gatshel	26.21	26.88	13.7
10	Punakha	15.65	9.99	2.6
11	Samdrup Jongkhar	37.98	21.01	6.2
12	Samtse	46.76	22.16	12.3
13	Sarpang	19.43	4.17	12.1
14	Thimphu	2.39	0.52	0.6
15	Trashigang	29.28	11.52	10.7
16	Trashy Yangtse	14.33	13.48	11.9
17	Trongsa	22.15	14.93	14.0
18	Tsirang	13.89	14.83	4.8
19	Wangdue Phodrang	15.84	10.94	5.4
20	Zhemgang	52.86	26.27	25.1
	Bhutan	23.20	12.04	8.2

Source: NSB, 2014 and NSB, 2017c

10.1.1.3 Economy

Bhutan averaged an annual gross domestic product (GDP) growth rate of 7.5 percent from 2006 to 2015, making it one of the fastest growing economies in the world (World Bank, 2015). The GDP of Bhutan was USD 1.2 billion in 2017; in 2016, the GDP per capita was USD 2 879 (SYB, 2017). In 2016, the primary sector (agriculture, livestock, and forestry) contributed 16.52 percent to the GDP. Cropping accounted for 9.5 percent of the GDP, with livestock at 3.5 percent, and forestry and logging at 2.68 percent. The secondary sector (manufacturing and industry) contributed 41.6 percent and the tertiary sector (service) contributed 42.02 percent to the GDP (NSB, 2017b).

In 2016, the current account deficit was 29.5 percent (NSB, 2017a), one of the highest in the world. Inflation was below 5 percent and, until recently, the exchange rate was relatively stable. Youth unemployment was

10.4 percent in 2017 (NSB, 2018). Foreign Direct Investment (FDI) inflow was a meager 1.7 percent of the GDP (World Bank, 2015).

10.1.1.4 Hunger and all forms of malnutrition

The National Nutrition Survey (2015) reported that of Bhutan's under 5 years old 21.2 percent were stunted, the prevalence of wasting was 4.3 percent, 9 percent were underweight and 2 percent were overweight. In the same survey found that the prevalence of anaemia was 43.8 percent for children aged 6 to 59 months, 31.3 percent for children and youth aged 10–19 years, 34.9 percent for non-pregnant women aged 15–49 years, 27.3 percent for pregnant women, and 7.8 percent for babies who had low birth weights. Aguayo *et al.*, (2014) indicated higher stunting in rural areas than urban areas. Chronic malnutrition was found in 21.2 percent of children between the ages of 6 and 59 months (WFP, 2017).

10.1.1.5 Poverty: population below the poverty line

Bhutan has made remarkable progress in fighting poverty (see Table 10.2). The theme of the 10th Five-Year Plan (2008–2013) was ‘Poverty Alleviation’, with various programmes formulated to address poverty. The Targeted Household Poverty Program identified and supported 3 154 of the poorest households in 1 359 villages (GNHC, 2014).

In 2012, Bhutan had an estimated national poverty rate of 12 percent, with about 95 percent of the poor population living in rural areas (GNHC, 2014). In 2017, the poverty rate had declined to 8.2 percent (NSB, 2017b). The national average rural poverty rate in Bhutan is 11.9 percent, which is significantly higher than the 0.8 percent in urban areas.

10.1.2 About the mountains in Bhutan

10.1.2.1 Physical characteristics, demographics

Bhutan is covered in mountains, with the exception of the foothills in the south that have gentle plains that stretch from 12 to 15 km wide along the southern border with India (Britannica, n.d.).

10.1.2.2 Economy: Major economic activities, sources of livelihood

Bhutan is largely an agrarian country as 56.6 percent of the population derive their livelihood from farming (NSB, 2015).

Of those that are employed, 43.9 percent are in the agriculture sector, 11.0 percent in the construction sector, 10.8 percent in public administration, and 5.6 percent in wholesale/retail trade. Other sectors include mining; manufacturing; wholesale and retail; hotels and restaurants; transport and communication; insurance, real estate, and business services; education and health; and private social and recreational services (NSB, 2017a).

10.1.3 About contributions and percentage of mountain agriculture in Bhutan

10.1.3.1 Land area, types, classification, distribution and utilization in the mountain areas

Since almost all of Bhutan is mountainous, nationally representative data can be used to explain the mountain agriculture scenario. The average landholding size is 2.22 acres per household. Total land ownership by regular Bhutanese households is 352 647 acres. Dryland accounts for 245 199 acres (70 percent), wetlands (paddy fields for rice) are 58 569 acres (17 percent), with the remainder (13 percent) being other types of

land (orchards, cardamom and land under housing). Land under fallow dryland (uncultivated) equates to 59 015 acres (16.7 percent) (NSB, 2018).

10.1.3.2 Main mountain agricultural activities and products

Bhutanese agriculture is largely based on the traditional subsistence-oriented mixed farming system that integrates cropping, livestock rearing and forest products. Rice is the staple crop. Domestic production accounts for half of the rice requirement. The population, particularly the poor, consume maize and other minor cereals such as millets and buckwheat to supplement their carbohydrate requirement. The principal cash crops in temperate areas include apples and potatoes, and in the sub-tropics, oranges, areca nut, cardamom and ginger are grown. Chillies and vegetables are other promising sources of revenue. Over one-third of Bhutanese households grow fruit, such as apple, orange, peach, plum, persimmon, pear, banana and mango; and nuts, such as walnut hazelnut and betel nut. Domesticated animals include cattle, goat, sheep, poultry and pigs. There are also fisheries. With abundant forests, farmers derive benefits including wild edible mushrooms, bamboo and cane, fern and fuelwood (NSB, 2015).

10.2 Mountain agriculture in Bhutan: Status, challenges and constraints

10.2.1 Land utilization in the mountain areas

Of the total geographical land, 71 percent is forest with protected areas accounting for 51.4 percent of this, 7 percent is covered with permanent snow and glaciers, 4 percent is meadows and pastures, 2.9 percent is cultivated agricultural land, and the rest is barren, rocky or scrubland.

10.2.2 Main farming systems in mountain areas

The various farming systems within the dryland and wetland cultivation practices is summarized below.

10.2.2.1 Subsistence mixed farming

Subsistence mixed farming is the dominant farming system. Farmers grow crops (mainly maize, paddy, wheat, buckwheat and vegetables) for self-consumption, and rear small numbers of livestock (cattle, pigs, poultry, etc.). Farmers usually follow

Table 10.3 Summary of the farming systems in different agro-ecological zones in Bhutan

Agro-ecological zones	Main farming system	Major source of livelihood	Major trends affecting farming system
Wet Subtropical	Subsistence, mixed farming, agriculture commercial farming, livestock farming, organic farming	Paddy pulses, tropical fruits, vegetables, cattle, poultry	Rural-urban migration, low soil fertility, high transportation costs, low value addition
Humid Subtropical		Maize, paddy cattle, piggery, poultry, vegetables, potatoes, temperate fruits, vegetables, cattle, sheep, horses	Rural-urban migration, competition for forest resources, high transportation costs, low value addition
Dry Subtropical			
Warm Temperate			
Cool Temperate			
Alpine	Subsistence, nomadic farming	Yaks, buckwheat	Low literacy, nomadic lifestyle, low technology adoption, high transportation costs, low value addition

Source: MoAF, 2015

traditional farming systems with low inputs and animal power for ploughing and other farm work. Animal waste serves as a valuable input for crop nutrient enhancement.

10.2.2.2 Nomadic farming

Nomadic farming is common among communities living in alpine and subalpine areas. People rear large numbers of cattle, yak or sheep for their livelihood. They either barter or sell their dairy products for basic necessities. Herdsmen often move around with their cattle, yak or sheep in search of fresh pastures.

10.2.2.3 Agriculture as commercial farming

Agriculture as commercial farming is a recent phenomenon made possible by modernization. Crops such as fruits, vegetables and plantation crops are grown on a commercial scale with investments in inputs, infrastructure and marketing. The system requires specialized skills and is usually undertaken by progressive farmers or implemented through FDI.

10.2.2.4 Livestock farming

Livestock farming, especially the raising of poultry, cattle and pigs, is gaining momentum. Unlike other countries, livestock farming in Bhutan is targeted mainly for dairy products rather than meat production due to religious sentiments.

10.2.2.5 Organic farming

Organic farming is increasingly being recognized and is becoming the desired system to harness the comparative advantage offered by Bhutan's unique and diverse physiography and environmental conditions.

A national organic research centre has been established to promote organic farming. Currently, there are 24 farmer groups/cooperatives, three organic retailers

and one exporter involved in organic production and marketing. Ten products have been certified as organic: potato, garlic, carrot, turmeric, sea buckthorn, chamomile, mint, tea, *Rhododendron anthopogon* and lemongrass.

The farming systems in Bhutan's various AEZs are detailed in Table 10.3.

10.2.3 Crops commonly grown in mountain areas

A wide variety of crops, cereals, vegetables and fruits are grown depending on the AEZ. Dryland crops include maize, upland paddy, buckwheat (both bitter and sweet), wheat, millet, barley and kitchen vegetable gardens. Traditionally, the wetlands were used solely for the cultivation of irrigated paddy, although in recent years such areas has been used for vegetable cultivation.

The main fruit crops include citrus mandarin, apple, areca nut, banana and pear. The most important export commodities from the agricultural sector are potato, mandarin, orange, betel nuts, apple and vegetables.

10.2.4 Animal production and grazing system in mountain areas

Animals are reared for food, milk, farm work and as household assets. Butter and cheese are an integral part of the Bhutanese diet. In the higher altitude areas, the main livestock are cattle and yak. Pigs, poultry and fisheries are becoming commercially important. Honey production is common in certain parts of the country.

Highlanders who rear yaks are given rights to pasture land. For cattle, grazing is done in the backyard, nearby forests or on government land.

10.3 Challenges and constraints for sustainable mountain agriculture

10.3.1 Socio-economic factors

Socio-economic constraints include:

- ◆ Labour shortages – number one farming constraint (DoA, 2016)
- ◆ Small landholdings
- ◆ Inheritance law allowing all siblings to inherit land, irrespective of the nature of their job resulting in land fragmentation
- ◆ Higher paying off-farm activities, leading to a shortage of agricultural labour
- ◆ Feminization of agriculture (59.3 percent women) as men move to urban areas in search of work. Much of the farm equipment and many farming tasks are not gender friendly
- ◆ High production costs
- ◆ Rural–urban migration, leading to a shortage of agricultural labour
- ◆ Self-help groups for agriculture have poor literacy, often lack expertise in record keeping and have poor access to information
- ◆ Poor savings culture exacerbated by low literacy and education levels
- ◆ High capital costs.

10.3.2 Natural resources and environment pressure on the agricultural production base

Bhutan is blessed with abundant natural resources like forests and water sources. However, strict conservation rules do not allow for optimal forest resource utilization. Moreover, farms are located adjacent to forests leading to human–wildlife conflict which can be another major farming constraint (DoA, 2016).

Despite having one of the highest per capita water availabilities in the world (94 500 m³ per person per year), Bhutan faces water shortages for drinking and irrigation (ADB, 2016). Agriculture is highly vulnerable to the impact of climate change, particularly changes in temperature and rainfall frequency, intensity and time.

In 2008, natural calamities such as windstorms affected the properties of 320 households. In 2004, monsoon rain

triggered heavy landslides that damaged 39 irrigation channels, 161 acres of wetland and 503 acres of dryland (NEC, 2011). This scale of damage is substantial for a small country like Bhutan.

Land degradation and soil erosion, nutrient leaching and the subsequent decline in soil fertility are major constraints for sustaining crop productivity.

10.3.3 Technical constraints for mountain agricultural production

Farm mechanization is difficult because of the terrain and the difficulty in accessing many of the rural areas. This makes farming labour-intensive and inefficient. Input use is low due to high costs. Crop varieties and livestock breeds are traditional and low yielding. In addition, controlling crop pests and diseases is challenging due to the difficulty in accessing chemicals. There is low investment in research.

10.3.4 Market

Marketing constraints include:

- ◆ Small domestic market
- ◆ Lack of road access in remote areas and lack of all-weather roads
- ◆ Lack of marketing infrastructure, such as cold storage and refrigerated trucks
- ◆ Weak market information systems
- ◆ Auction yards do not have adequate logistics
- ◆ Low-quality processing, branding and labelling
- ◆ Farmers unable to conform to internal market requirements e.g. labelling or nutritional contents, branding etc.
- ◆ Inability to link smallholder farmers to the international value chain.

10.3.5 Physical and infrastructure constraints

Road connectivity remains a constraint. According to the Census of Bhutan, 91.6 percent of households walk less than 30 minutes to reach the road point, while 0.7 percent of households walk more than 6 hours to reach the road point (NSB, 2017). A 30-minute walk in a mountainous country poses major problems in bulking of farm produce and transportation. Rural roads need to be weatherproof for all seasons.

Irrigation coverage is only 18 percent of the total cultivated area; this needs further investment for expansion and climate proofing. Cold storage facilities are concentrated only in a few locations. Research centres do not have adequate infrastructure, such as laboratories, and other facilities.

10.3.6 Policy and institutional constraints

The Renewable Natural Resources (agriculture, livestock and forestry) Marketing Policy of Bhutan (MoAF, 2018) provides strategic direction for the marketing of farm produce. The fact that this policy only came about in 2018 indicates that marketing has not received adequate support in the past. Investment in the agricultural sector has been declining. Most of the agricultural sector funds are allocated to infrastructure, such as farm roads and irrigation channels, leaving farm production support with inadequate funding.

10.4 Opportunities and entry points for mountain agriculture development to address Zero Hunger and poverty reduction

10.4.1 Agriculture diversification and sustainable intensification

Farming in Bhutan is primarily based on rice or maize, but diversification is needed. Harnessing traditional and minor crops and improved animal breeds will help to improve food and nutritional security and enhance household income in Bhutan.

Moreover, with commercialization gathering momentum, it is important that farming intensification occurs in a sustainable manner to protect soil health. Agro-ecological intensification will benefit mountain farming, given the risk of soil erosion and land degradation. Sustainable agro-intensification is possible in all farming systems including commercial farming. Local plant biomass, leaf litter, compost, farm manure and cow dung are important inputs for soil fertility improvement. Cow urine mixed with neem and chilli will help to manage pests and diseases.

The food basket needs to be diverse and nutritious. Support for minor crops that are future smart foods (Table 10.4) will help to reduce the dependence on the primary staple food, in Bhutan, which is rice.

10.4.2 Agroprocessing activities and value addition for agricultural products

The mountainous terrain and scattered settlements of Bhutan make agroprocessing and value addition cumbersome. Transport of raw materials is expensive. Moreover, produce can spoil due to roadblock delays. Setting up small-scale facilities will allow local produce to be sold within local regions. Most agricultural and livestock products are sold in raw form; so there is immense opportunity for value addition.

The farm shops (government subsidized outlets for supply of farm inputs, groceries and last resort markets for farm produce) offer a buy-back mechanism to cushion farmers against price drops and market gluts. This mechanism needs fine-tuning. The initiative of One Geog (Sub-district) – One Product needs further investment especially in value addition, branding and marketing.

10.4.3 Organic farming

Historically, Bhutanese farming has had an integrated approach for sustaining soil health, ecological processes, biodiversity, nutrient cycles and livelihoods. Agrochemicals are used by 31 percent of farmers (Nkonya *et al.*, 2014). This provides a strong basis for the expansion of organic farming. Bhutan embraced organic farming with the adoption of the *National Framework for Organic Farming in Bhutan* in 2006. Decent progress has been made since then. For example, 2 680 households were engaged in organic farming (crops, livestock and non-wood forest product collection) in the 11th Five-Year Plan (2013–2018), and 25 669 acres of land were under organic management. The pristine environment, coupled with globally recognized conservation efforts, will enable products to be sold under Brand Bhutan, which is organic. The 12th Five-Year Plan (2018–2023) has approved organic farming as a flagship programme that will receive major investment.

10.4.4 Social protection measures targeting mountain people

Farming incentives that are provided, must evolve to ensure clear guidelines and targeting. Traditional farming support services, such as the provision of free seeds, will not yield the desired results. Any support needs to empower the farming community rather than make them dependent. Politicians need to refrain from offering handouts (especially during election campaigns) that result in short-term solutions. Support for capacity building, value addition, logistics and penetration of the global value chain are important for sustainable

Table 10.4 List of Future Smart Food in Bhutan

Future smart foods	Major districts	Category	Type of crop	Nutrients	Altitude (masl)	Latitude	Longitude	Soil (pH)	Min temperature (average)	Max temperature (average)	Rainfall (mm)	Growing period
Finger millet (<i>Eleusine coracana</i>)	Samtse, Sarpang, Pema Gatsel, Chhukha, Dagana, Tsirang	Minor crop	Cereals		500–2 700	20–35		5.5–8.2	15	30	300–4 300	June/July to November/December
Sweet buckwheat (<i>Fagopyrum esculentum</i>)	Bumthang, Chhukha, Dagana, Haa, Samdrup Jongkhar, Trashigang, Trongsa	Minor crop	Cereals		500–2 000	60–60		4.4–7.5	10	38	400–1 300	March to November (high altitude) Mar/April to June/July (low altitude paddy field) July to November/December (low altitude dryland)
Bitter buckwheat (<i>Fagopyrum tataricum</i>)	Bumthang, Chhukha, Dagana, Haa, Samdrup Jongkhar, Trashigang, Trongsa	Minor crop	Cereals		500–2 000	60–61		4.4–7.6	10	38	400–1 300	March to November (high altitude) March/April to June/July (low altitude paddy field) July to November/December (low altitude dryland)
Barley (<i>Hordeum vulgare</i> L)	Bumthang, Mongar, Trongsa, Wangdue, Gasa	Minor crop	Cereals	High protein, dietary fibre and vitamin B	1 200–4 400	55–70		6.0–8.0	5	40	200–2 000	November to April
Quinoa (<i>Chenopodium quinoa</i>)	Haa, Paro, Samtse	Minor crop	Cereals	High protein	200–4 000	30–40		4.5–9.5	2	35	250–2 600	March/April to September/October (high altitude) October/November to March/April (low altitude)
Foxtail millet (<i>Setaria italica</i>)	Pema Gatsel, Trashigang, Samdrup Jongkhar	Minor crop	Cereals		600–2 100	25–30		5.5–8.3	5	35	300–4 000	March/April to September/October
Amaranth (<i>Amaranthus</i> spp.)	Central and South	Minor crop	Cereals	High protein	900–2 600	30–30		4.3–8.5	7	45	250–4 150	April/May to October/November

Source: Pradhan and Chettri, 2018, Tyagi *et al.*, 2018, DoA, 2016, Katwal, 2013, World Bank, 2013, NiN, 2017, NSC, 2017, Kunzang, Kesang and Walter, 2013, Ecocrop (n.d.), ISC (n.d.)

Table 10.4 List of Future Smart Food in Bhutan (*continued*)

Future smart foods	Major districts	Category	Type of crop	Nutrients	Altitude (masl)	Latitude	Longitude	Soil (pH)	Min temperature (average)	Max temperature (average)	Rainfall (mm)	Growing period
Tapioca (<i>Manihot esculentus</i>)	Southern region	Minor crop	Roots and tubers		0–2 000	25–30		4.0–9.0	10	35	500–5 000	April/May to November/December
Sweet potato (<i>Ipomoea batatas</i>)	Southern region	Minor crop	Roots and tubers		0–2 500				10	38	350–5 000	April/May to August/September
Greater yam (<i>Dioscorea alata</i>)		Minor crop	Roots and tubers		0–2 500	30–40		4.8–8.5	14	40	700–8 000	May/June to October/November
Taro (<i>Colocasia</i>)	Central and South	Minor crop	Roots and tubers		0–2 700	18–35		4.3–8.2	10	35	1 000–4 100	May/June to November/December
Kidney beans (<i>Phaseolus vulgaris</i>)	Trashigang, Mongar, Dagana, Tsirang	Minor crop	Pulse	High protein	0–3 000	20–60		4.0–9.0	7	32	300–4 300	August/September to November/December
Mung beans (<i>Vigna radiata</i>)	Dagana, Sarpang, Tsirang, Samtse	Minor crop	Pulse	High protein, fibre, vitamin and minerals	0–2 000			4.3–8.3	8	40	500–1 250	June/July to October/November
Urd beans (<i>Vigna mungo</i>)	Dagana, Sarpang, Tsirang, Samtse	Minor crop	Pulse	High protein, fibre, vitamin and minerals	0–2 000			4.5–7.5	8	40	530–2 430	June to November

Source: Pradhan and Chettri, 2018, Tyagi *et al.*, 2018, DoA, 2016, Katwal, 2013, World Bank, 2013, NiN, 2017, NSC, 2017, Kunzang, Kesang and Walter, 2013, Ecocrop (n.d.), ISC (n.d.)

Table 10.4 List of Future Smart Food in Bhutan (*continued*)

Future smart foods	Major districts	Category	Type of crop	Nutrients	Altitude (masl)	Latitude	Longitude	Soil (pH)	Min temperature (average)	Max temperature (average)	Rainfall (mm)	Growing period
Soybean (<i>Glycine max</i>)	Pema Gatsel, Trashigang, Mongar	Minor crop	Pulse	High protein and dietary fibre	0–3 000	47–52		4.5–8.4	10	38	450–1 800	April/May to September/October
Lentil (<i>Lens culinaris</i>)	Sarpang, Dagana	Minor crop	Pulse	High protein	0–3 000	45–55		4.4–8.2	5	32	250–2 500	October/November to March/April
Horse gram (<i>Macrotyloma uniflorum</i>)	Dagana, Tsirang	Minor crop	Pulse		0–1 800	40–50		4.3–8.0	14	36	600–4 300	June/July to October/November
Rice beans (<i>Vigna umbellata</i>)	Tsirang, Dagana, Sarpang	Minor crop	Pulse	High protein	0–2 000	25–30		5.5–8.0	10	40	300–2 000	June/July to October/November
Field pea (<i>Pisum sativum</i>)	Chhukha, Haa, Paro	Minor crop	Pulse	High protein and fibre	0–2 700	60–70		4.5–8.3	4	30	350–2 500	February/March to June/July (mid altitude); November/December to July/August (High altitude)
Drum stick (<i>Moringa oleifera</i>)	South		Vegetable		0–1 000	20–30		5.0–8.5	7	48	400–2 600	Planting June/July; flowering/fruiting: April/May
Amaranth (<i>Amaranthus</i> spp.)		Minor crop	Vegetable		900–2 600	30–30		4.3–8.5	7	45	250–4 150	February/March to June/July

Source: Pradhan and Chettri, 2018, Tyagi *et al.*, 2018, DoA, 2016, Katwal, 2013, World Bank, 2013, NiN, 2017, NSC, 2017, Kunzang, Kesang and Walter, 2013, Ecocrop (n.d.), ISC (n.d.)

development. Compensation for the loss of crop and livestock during disasters is not enough, and crop insurance needs to be institutionalized.

10.4.5 Other efforts

The variation in agro-ecological zones offers possibilities for seasonal production of some commodities for export to India during the hot season as well as the cultivation of products not suited to other areas in South Asia. Several export products have already been successfully developed, including cardamom, mandarin, potato, ginger and *Cordyceps* (high altitude fungus). However,

this needs further support. Enterprise farming must appeal to youth and offer incentives such as access to credit and markets, along with capacity building.

10.5 Country experience

10.5.1 Good agricultural practices (GAP) on sustainable and integrated farming in mountain areas

Restrictions on the use of chemicals have helped to promote GAP in agriculture. The promotion of bio-inputs (biofertilizer, pesticides, green matures etc.) will further

enhance sustainable agricultural practice. For resilience of the farming community, conservation of traditional crop varieties and livestock breeds must continue. Sustainable land management practices must continue and expand. Emphasis needs to be placed on GAP certification.

10.5.2 Policy measures and initiatives for sustainable and inclusive mountain development

Priority Sector Lending (PSL) is a scheme launched in April 2018 where banks provide collateral-free loans of up to USD 7 700 with an interest rate below 8 percent (the average interest rate in the market is 10 percent) to start/expand farming activities. In addition, 2.9 percent of the loan amount goes directly to the insurance company; so farmers are cushioned against major perils like fire, wildlife damage and other natural calamities. Farmers can avail loans with an insurance facility to a maximum of USD 150 000 under the PSL. The Royal Monetary Authority of Bhutan (the country's central bank) provides incentives to banks if the loans are provided under the PSL scheme.

The Economic Development Policy of Bhutan (2010) highlighted the following areas for agricultural development:

- ◆ Production and productivity of agricultural crops
- ◆ Production and productivity of livestock products
- ◆ Access to high-quality inputs
- ◆ Improved agriculture marketing
- ◆ Access to finance
- ◆ Biodiversity conservation
- ◆ Sustainable management and utilization of natural resources
- ◆ Private sector promotion through appropriate incentives
- ◆ Promotion of adoption of new technology.



The School Agriculture Programme aims to educate school children on the importance of farming and healthy eating. The rice-fortification programme, with the support of the World Food Programme (2017), is helping to supplement nutrients in the school-feeding programme. It is looking forward to fortifying rice for other institutions such as Buddhist orders, hospitals and the armed forces.

10.5.3 Case study: The promotion of horticulture as a source of income

Background

In Bhutan, the Eastern Region is home to 24 percent of the total population (NSB, 2018). The region has one of the highest poverty incidences in the country. Therefore, Japan International Cooperation Agency supported a five-year technical cooperation project –the Horticulture Research and Development Project (HRDP) – implemented by the Agriculture Research and Development Centre, Wengkhar, Mongar from 2010 to 2015, with the overall goal of promoting horticulture as a source of income.

Intervention

- ◆ Awareness of improved technologies through study tours, field days and exhibitions
- ◆ Capacity building through systematic hands-on training
- ◆ Training of vegetable seed producers and nursery fruit growers
- ◆ Establishment of an integrated model of new demonstration orchards and commodity-focused villages.

Output

- ◆ More than 1 000 farmers, in addition to researchers and extension officers, were trained on various aspects of horticultural crops such as seed quality and seedling production, canopy management, post-harvest processing and marketing
- ◆ More than 50 000 grafted quality fruit plants and 500 kg of vegetable seeds produced
- ◆ Around 2 200 acres under horticultural crops by establishing integrated mixed-fruit model orchards, commodity-focused villages and vegetable outreach villages.

Outcome

- ◆ More than 73 percent of farmers reported increased production after project intervention
- ◆ Overall average income of farmers increased to Nu. 15 790 from baseline income of Nu. 8 400
- ◆ Fruit nursery growers earned the highest annual income of Nu. 51 180
- ◆ About 70 percent of farmers now sell their produce.

Impact

The project had a significant positive contribution to people's wellbeing when viewed through the Gross National Happiness domains:

- ◆ **Living standard:** increased farmers' income by about 88 percent
- ◆ **Community vitality:** fostered community relationships and trust through the interactions and exchange of knowledge and skills among more than 1 000 farmers from six districts
- ◆ **Ecological diversity and resilience:** increased crop diversity, contributing to ecological diversity and resilience with the introduction of 25 fruits and 22 vegetables
- ◆ **Health:** the introduced fruits and vegetables have provided a rich source of vitamins and minerals.

10.6 Strategic consideration and suggestion

10.6.1 Policies

The Food and Nutritional Policy of Bhutan (2014) provides a framework for improving food and nutritional status. While there has been a concerted effort to enhance food security, little has been done to support the nutritional component, which urgently needs renewed focus.

There has been a major push to increase the national self-sufficiency of rice, which is the primary staple crop. In the 12th Five-Year Plan (2018–2023), the national rice target is 60 percent (up from 47 percent in the previous five-year plan). Production costs for rice are high due to high labour costs and low productivity. Rather than the government investing heavily in rice, support for other cereals will help to increase cereal self-sufficiency.

A comprehensive long-term vision is needed to develop mountain agriculture.

Governance challenges (leakage, kickbacks, wastage, etc.) of farming input distribution by the government needs to be assessed. Moreover, the National Food Security Reserve, retained by Food Corporation of Bhutan Limited, needs further investment for expansion and rotation of old stocks.

10.6.2 Measures and interventions

Technologies suitable for different AEZs need to be developed. Forest resources need to be tapped sustainably. Enterprise farming should be promoted, and intervention in markets and trade is needed.

10.6.3 Governance

Good governance is one of the four pillars of Bhutan's development philosophy of *Gross National Happiness*. It has received due importance from the government, and recognition from donors that the governance system in Bhutan is well established. Governance can be improved by:

- ◆ Formulating a long-term vision/plan.
- ◆ Institutionalizing services (soil, plant protection, seeds) at the regional level.
- ◆ Putting a grievance redressal mechanism in place at the district level.

10.7 Conclusion

Mountain agriculture has a unique set of challenges. Considering the limited area of cultivation in the Bhutanese mountains, vertical expansion in terms of productivity gains through agro-ecological intervention and sustainable practices will help to enhance food and nutritional security. Policies geared towards empowering the farming community need to be formulated and implemented. Bhutan's pristine environment and natural way of farming, coupled with support for enterprise farming, offer immense opportunities for making farming a profitable venture and addressing poverty.

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11 India

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11.1 Overview

11.1.1 About the country

India is situated to the north of the equator between 8° 4' to 37° 6' North and 68° 7' to 97° 25' East. It is the seventh largest country in the world and has a total area of 3 287 469 km². India measures 3 214 km from north to south and 2 933 km from east to west. It has a land frontier of 15 106.70 km and a coastline of 7 516.60 km. It is the second most populous country with over 1.25 billion people. It is bound by the Indian Ocean to the south, the Arabian Sea to the southwest, and Bay of Bengal to the southeast. India has six major climatic subtypes, ranging from arid desert in the west, and alpine tundra and glaciers in the north, to humid tropical regions supporting rainforests in the southwest and island territories. The country has four seasons: winter (January–February), summer (March–May), monsoon (rainy) (June–September) and post-monsoon (October–December).

India is one of the world's fastest-growing economies. In 2017, the Indian economy was the third-largest country by purchasing power parity (PPP) with an average annual gross domestic product (GDP) growth rate of 5.8 percent in the past two decades, reaching 6.1 percent between 2011 to 2012. The service sector makes up 55.6 percent of the GDP, the industrial sector 26.3 percent and the agricultural sector 18.1 percent.

11.1.2 Mountain ranges in India

India has seven major mountain ranges:

◆ Himalayas

The most famous mountain range in India is the Himalayas, which has the youngest and highest mountains in the country. Kanchenjunga is the highest mountain in India and the third highest in the world. Nanda Devi is the second highest mountain in the Himalayas. The world's second longest non-polar glacier, Siachen Glacier, is part of the Himalayas.



◆ Purvanchal Range

The Purvanchal Range is an extension of the Himalayas in the northeast of India. This range covers seven eastern states of India, commonly known as the Seven Sisters. Mawsynram, in Meghalaya is the wettest place on Earth because of these hills.

◆ Satpura and Vindhya Ranges

The Satpura and Vindhya Ranges lie in central India and run parallel to each other. The Satpura Range is higher than the Vindhya Range and is the origin of several rivers including the Narmada and Tapti Rivers. Both ranges are situated mainly in Madhya Pradesh and Maharashtra with some extension to Gujarat, Chattisgarh and Uttar Pradesh. The Kalumar peak (752 m) and Dumphgarh peak (1 350 m) are the highest points in the Vindhya and Satpura Ranges, respectively.



◆ Aravalli Range

The Aravalli Range, also known as Mewat Hills, is one of the oldest and most visited mountain ranges in India. It runs from Rajasthan to Haryana, and plays an important role in the Indian climate as it blocks the wind-carrying rain from reaching the Thar Desert.



◆ Western Ghats

The Western Ghats, also known as Sahyadri, start near the border of Gujarat and run about 1 600 km to their end at Marunthuvazh Malai, near the southern tip of India. About 60 percent of the Western Ghats are in the state of Karnataka. This area is one of the world's top ten biodiversity hotspots.

◆ Eastern Ghats

The Eastern Ghats are a discontinuous range of mountains that run parallel to the Bay of Bengal from West Bengal to Tamil Nadu and include four major rivers: Godavari, Mahanadi, Krishna and Holy Kaveri. The Nilgiri Hills or 'Blue Mountains' in Tamil Nadu lie at the junction of the Eastern and Western Ghats. The Shevaroy Hills are the highest peaks in the Eastern Ghats.

11.1.3 The Indian Himalayas

The mountain areas in India are vastly distributed with larger areas located in the Himalayas, extending up to 2 500 km in length and 250 to 400 km in width (Khanday *et al.*, 2004), with a landmass of 650 000 km² spread across China, India, Nepal, Myanmar and Bangladesh. About 85 percent of the Indian Himalayas landmass occupies 16.4 percent of the country's area. The Indian Himalayas are divided into the north-western Himalayas (331 392 km²) and north-eastern Himalayas (262 179 km²) (Bakshi and Sharma, 2011) (Table 11.1).

The Indian Himalayan region is 53.8 million hectares and is home to 34 million people, largely hill farming communities that survive on subsistence farming on the marginal rain-fed or in some cases irrigated farmland

that occupies 15.8 percent of the total area. Almost 69 percent of the Himalayan landscape is comprised of rangelands, pastures, wastelands and forests. The remaining 15 percent is permanently covered with snow and provides a perennial flow of water (1 200 km³ annually) to the vast Indo-Gangetic plains (Chandra, 1994). The area under different agricultural activities in various regions of the Indian Himalayas is shown in Figure 11.1.

Agriculture is the primary sector of the Indian Himalaya contributing 45 percent to the total regional income of the inhabitants. However, more than 90 percent of the farmers in the hill and mountain areas are marginal, cultivating less than one hectare of land (Partap, 1995; Koirala and Thapa, 1997 and Partap, 1999). The average land holding is about 1.2 ha in Himachal Pradesh, 1.01 ha in Uttarakhand and 0.76 ha in Jammu and Kashmir (Table 11.2). Due to declining soil fertility, crop productivity and crop quality, many mountain families are facing food shortages that contribute to the cyclical process of poverty–resource degradation–scarcity–poverty (Jodha and Shrestha, 1993). In the Indian Himalayas, 76 percent of the gross cropped area is sown for grain crops, but figure ranges from 55 percent in Meghalaya to 88 percent in Manipur. The remaining area is used to grow vegetables, fruits and oil seeds.

The two Himalayan regions show distinct crop preferences. In the North-Eastern Hill Region, rice is the staple food and occupies 81 percent of the total area under food grains, followed by maize (12.7 percent). Wheat is cultivated in small areas in Arunachal Pradesh, Meghalaya, Sikkim and Tripura. In contrast, wheat is the principal crop (36.4 percent) in the North-Western Region, followed by rice (30.7 percent) and maize (26.3 percent). Millet is confined to the hill region of Uttarakhand. The cultivation of pulses and oil seeds is restricted to small areas only.

Figure 11.2 shows the average yields of food grain crops in the three North-Western Region states in 2015/16, all of which were below the national average. The predominant farming systems in various zones of the Indian Himalayas are presented in Table 11.3.

11.2 Mountain agriculture in India

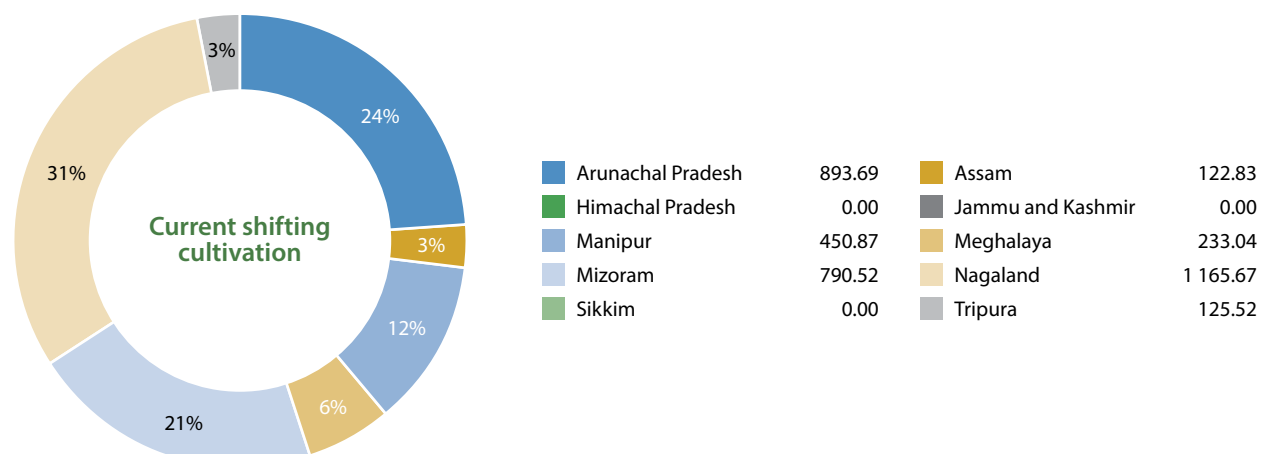
Mountain agriculture plays a crucial role in sustaining about 10 percent of the world's population. In addition, mountains provide 60 to 80 percent of the world's freshwater, essential for domestic consumption, irrigation, industry, food and energy production. Due to the poor potential for industrialization in the mountains,

Table 11.1 The mountainous regions and climatic areas of the Indian Himalayas

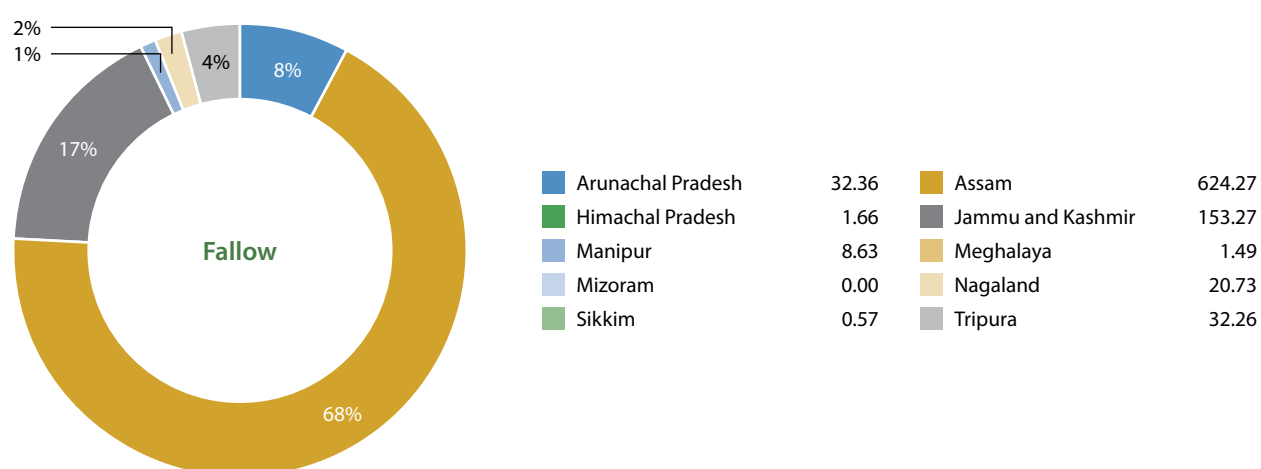
State/region	Areas
North-western region	
Himachal Pradesh	<ul style="list-style-type: none"> ◆ Sub-Montane and Low Hills Sub-Tropical Zone: Uplands of Chamba, Kangra, Solan, Hamirpur, Sirmaur and Biaspur districts ◆ Mid Hills Sub-Humid Zone: Parts of Chamba, Kangra, Mandi, Solan, Shimla and Sirmaur districts ◆ High Hills Temperate Wet Zone: Kullu and parts of Chamba, Kangra, Mandi, Sirmaur and Shimla districts ◆ High Hills Temperate Dry Zone: Kinnaur, Lahual-Spiti and parts of Chamba district
Jammu and Kashmir	<ul style="list-style-type: none"> ◆ Low-Altitude Sub-Tropical Zone: Kathua, footlands of Jasrota, Samba and Jammu ◆ Mid- to High-Altitude Intermediate Zone: Poonch, Rajouri and Doda ◆ Mid- to High-Altitude Temperate Zone: Anantnag, Oikwanam, Srinagar, Baramulla and Kupwara ◆ Cold Arid Zones: Leh and Kargil districts of Ladakh
Uttarakhand	<ul style="list-style-type: none"> ◆ Hill Zone: Uttarkashi, Chamoli, Pauri Garhwal, Tehri Garhwal, Dehradun, Pithoragarh, Almora and Nainital ◆ Hill Zone: Uttarkashi, Chamoli, Pauri Garhwal, Tehri Garhwal, Dehradun, Pithoragarh, Almora and Nainital
North-eastern region	
Arunachal Pradesh	Dibang Valley, Changlang, East Siang, West Siang, West Kameng, Lower Subansiri, Upper Subansiri and Lohit districts
Assam	Karbi Anglong and North Cachar districts
Manipur	Senapati, Chandel, Tamenglang, Ukhrul and Churachandpur districts
Meghalaya	Jaintia Hills, East Khasi Hills, East and West Garo Hills
Mizoram	Aizawl, Lunglei and Chhimtuipui
Nagaland	Kohima, Phek, Zonheboto, Wokha and Mokokchung, Tuensang and Mon districts
Sikkim	East Sikkim, North Sikkim, West Sikkim and South Sikkim districts
Tripura	Tripura

agriculture remains an important sector for the livelihoods of people living in these areas. Mountain agriculture covers all land-based activities such as cropping, horticulture, animal husbandry, forestry, water harvesting and resource conservation practices. Food grain production in the Indian Himalayas has remained stable in recent decades, but may decline in the future, largely due to a shift to cash crops such as fruits and vegetables (Partap, 2011). Such diversity or heterogeneity, 'niche' or comparative advantages, and human adaptation mechanisms (Jodha, 1990; Jodha *et al.*, 1992) are inextricably linked with mountain agriculture, and could have great potential for contributing to national and international economies.



Figure 11.1 Agricultural activity in different states in the Indian Himalayas (km²)

Note: Himachal Pradesh, Jammu and Kashmir, and Sikkim have little or no shifting cultivation



Note: Meghalaya has no recorded area of fallow

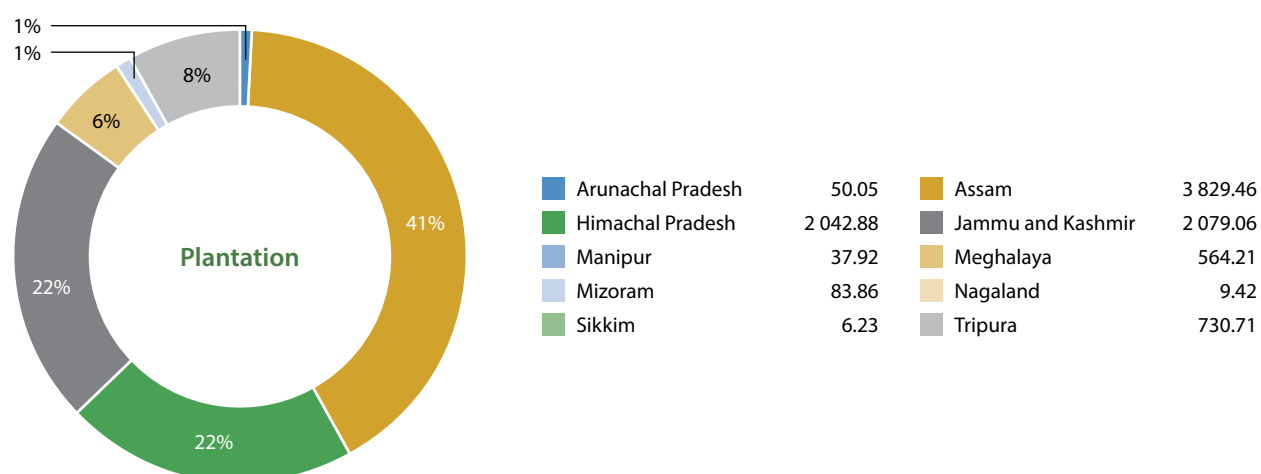
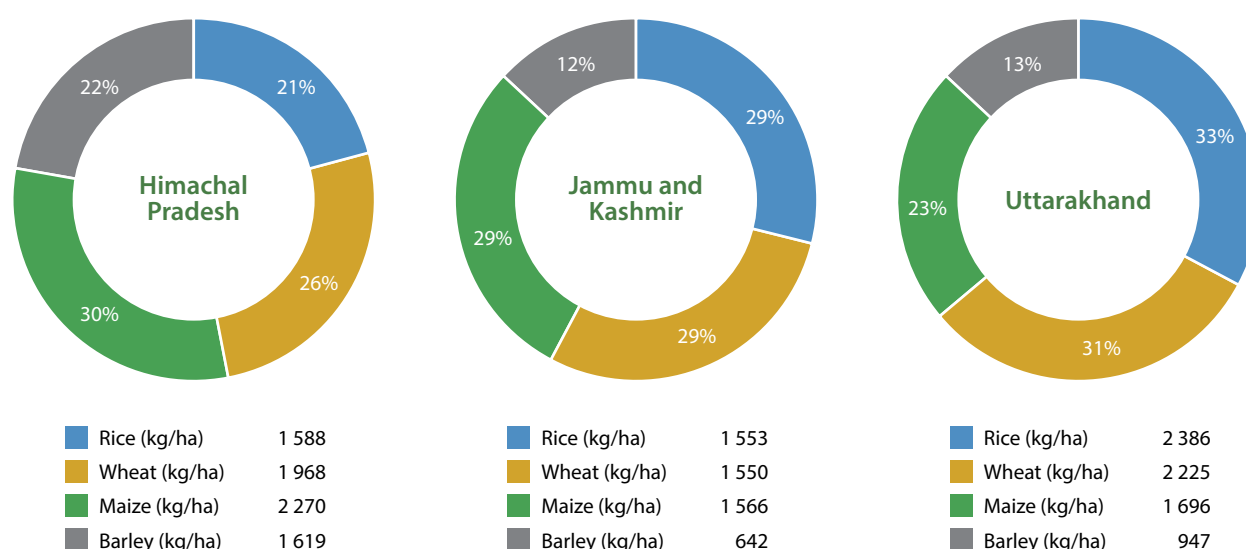


Table 11.2 Demographics and agriculture indicators in the Indian Himalayas

State	Geographical area ('000 ha)	Population (number of people)	Population density (per '000 ha)	Area under forests ('000 ha)	Net cropped area ('000 ha)	Net cropped area (% of total area)	Cropping intensity (%)	Average size of holdings per family (ha)
North-western hill region								
Himachal Pradesh	5 567	6 864 602	1 233	1 470	550	12.16	174	1.16
Jammu and Kashmir	22 224	12 541 302	564	2 299	741	16.27	147	0.76
Uttaranchal	5 348	10 086 292	1 886	2 424	701	14.91	164	1.01
Sub-total	33 139	29 492 196	890	6 193	1 992	14.47	160	0.97
North-eastern hill region								
Arunachal Pradesh	8 374	1 383 727	165	6 725	225	3.02	159	3.31
Assam	7 844	31 205 576	3 978	2 762	2 820	34.41	152	1.17
Manipur	2 233	2 855 794	1 279	1 699	377	6.33	142	1.22
Meghalaya	2 243	2 966 889	1 323	1 722	286	10.71	111	1.33
Mizoram	2 108	1 097 206	521	1 875	114	4.31	100	1.29
Nagaland	1 658	1 978 502	1 193	1 297	380	16.73	113	4.82
Sikkim	710	610 577	860	335	77	13.38	127	1.65
Tripura	1 049	3 673 917	3502	781	277	26.41	152	0.60
Sub-total	26 219	45 772 188	1 746	17 196	4 556	17.09	145	1.92
Total	328 724	1 210 854 977	3 684	70 167	141 372	46.15	142	1.41

Figure 11.2 Average yields of food grain crops in the three states of the North-Western Hill Region of the Indian Himalayas

Source: Agriculture-Statistical Year Book India 2017, Ministry of Statistics and Programme Implementation, Government of India.
<http://mospi.nic.in/statistical-year-book-india/2017/177>

Table 11.3 Predominant farming systems in different zones of the Indian Himalayas

Component	Zones			
	Sub-montane lowhills	Mid hills sub-humid	High hills temperate wet	High hills temperate dry
Farming systems	Agriculture, livestock, horticulture	Agriculture, horticulture, livestock, silvipasture	Horticulture, livestock, pastoral, agriculture	Livestock, pastoral, agriculture, horticulture
Food and other crops	Wheat, maize, rice, oilseeds, pulses, sugarcane	Wheat, maize, rice, oilseeds, pulses	Maize, wheat, millets, ragi, apricot (<i>Prunus-Chuli</i>)	Buckwheat, barley, apricot (<i>Prunus-Chuli</i>)
High-value crops	Vegetables, ginger, turmeric	Off-season vegetables, ginger, turmeric	Seed potato, off-season vegetables	Off-season peas, seed potato, blackzeera, saffron, hops (<i>Humuluslupulus</i>), other vegetables
Fruits	Mango, citrus, litchi, peach, apricot	Stone fruits, citrus, mango, peach, apricot (<i>Prunus-Chuli</i>), pear	Apple, almond, pear, nuts	Apple, dry fruits, chilgoza (<i>Pinusgerardiana</i>), nuts
Flowers	Marigold	Gladiolus, marigold, carnation	Tulip, lily, carnation	–
Medicinal plants	Amla (<i>Phyllanthusemblica</i>), bhehra (<i>Terminaliabelerica</i>)	Amla, bhehra	Seabuckthorn (<i>Hippophae</i> L.)	Seabuckthorn (<i>Hippophae</i> L.), Kuth (<i>Saussurealappa</i>)
Livestock	Buffalo, cow	Cow, buffalo	Sheep, goat, cow	Sheep, goat, cow, yak
Fodder trees	Grewia, celtis, leucaenea, robinia, khair, bauhinia	Grewia, khair, bauhinia, morus	Salix, morus, quercus	Salix, poplar, robinia, morus, quercus
Subsidiary enterprises	Apiculture, silviculture, fisheries	Apiculture, mushroom, rabbitary	Apiculture	Apiculture

11.2.1 Agriculture

Nearly 80 percent of the Indian Himalayan mountain region is under wheat, maize and paddy cultivation. Other crops include pulses, oil seeds, millets, and vegetables and fruit crops. In the high hills, farmers also grow crops such as buckwheat, saffron, blackzeera and grain amaranth. The major cropping systems are maize–wheat, paddy–wheat, and the intercropping of pulses and oil seeds with maize and wheat. At lower altitudes of the north-western cold desert, rotational farming is traditionally practiced to increase production. Barley, pea and wheat are commonly used in these rotations. In higher reaches, wheat or barley cultivation is followed by a fallow period in winter. In the Spiti Valley, Kinnaur and the higher reaches of the Shimla district, monocropping prevails. Crops such as potatoes and peas are sown in April and harvested from September to October (Kumar *et al.*, 2017). In the areas that cultivate rice, wheat, maize, most pulses and oilseed crops are not usually profitable; suitable alternate crops include Rajmash (French bean, *Phaseolus vulgaris* L.), black gram, ricebean, kulthi, Amaranthus, buckwheat, proso millet, fox tail millet and finger millet. Intercropping enables

farmers to diversify their cropping systems by adding legume, oilseeds, fodder, vegetables, floriculture, fruit nurseries, etc. Crop diversification will lead to yield stability, reduced pest and disease infestations, and higher profitability per unit time.



11.2.2 Horticulture

The Himalayan region has wide agroclimatic variation from sub-tropical to alpine that provides scope for growing a large number of fruits such as mandarin, sweet orange, mango, guava, banana, lychee, apple,

peach, plum, pecannut, walnut, cherry, almond, strawberry, kiwi, and vegetables such as tomato, radish, potato, pea, cabbage and cauliflower, as well as flowers such as tulips, orchids, marigolds and chrysanthemum, and cash crops such as ginger, cardamom and chilli (Bakshi and Sharma, 2011). The total area under fruit and vegetable cultivation in the Indian Himalayan states is estimated to be about 16 percent of the gross cropped area, compared with 4 percent as the country average. The proportion of land under horticultural crops is much higher in the Western Himalayan Region states (20 percent of net cultivated area) than the North-Western Region states (5 percent). The hills are able to cultivate vegetables and other plants in off-seasons; and so these are known as off-season vegetables.

The major fruit crops in the North-Western Region of the Indian Himalayas are apple, apricot, walnut (*Juglans regia*) and citrus fruits. Himachal Pradesh is known as the apple bowl of the country but lacks high-quality planting material and proper management technology. Poor fruit set and fruit drop has affected productivity.



11.2.3 Agroforestry

Agrisilvicultural practices are common in the Himalayan region. A homestead or home garden in the mountains has a traditional practice that incorporates a number of tree species along with livestock, poultry and fish in a multi-tier canopy configuration. The upper tier consists of fodder trees such as *Celtis australis* (*khirak*), *Bauhinia variegata* (*kachnar*) or *Grewia optiva* (*bihul*). The middle tier consists of bushes such as *Adhatodavasicia*, *Vitex negundo*, lemon (*Citrus limon*) and galgal (*Citrus aurantifolia*). Cucurbits (vines) are grown along with colocacia (*Colocasia esculenta*), turmeric (*Curcuma longa*) in the rainy season and vegetables in

the winter season. Similarly, an agrihorticultural system is predominantly followed in the Mid Hills Sub-humid Zone and High Hills Temperate Wet Zone, with fruit trees grown on terraced beds alongside agricultural crops.



11.2.4 Livestock

Livestock is an integral part of farming system in mountainous India and a lively 'bridge' connecting two land types: uncultivated forest and cultivated land. Forests are a rich repository of nutrients, which subsidize the cultivated land (Singh, 1998). These nutrients are transferred to the cultivated land via the livestock. The Indian Himalayas support about 50 million domestic animals (1.6 animal/ha), which include cattle (47.5 percent), goats (15.8 percent), buffaloes (12.3 percent) and sheep (10.4 percent). Livestock produce includes dairy products, meat, wool and manure. Certainly, there is more livestock in the Indian Himalayas than on the plains as they provide economic and livelihood security to both the landowners and landless farm families. The technologies available for increased productivity with respect to animal husbandry include migratory grazing by shepherds, health care, breed type, management and veterinary prescriptions. At the onset of winter (October/November), the shepherds migrate their cattle along with flocks of sheep and goats from Bharmour and Lahaul to Kangra Valley and Pathankot to avoid fodder scarcity. In early April, these shepherds return to their respective villages with their cattle to manure the fields during the early growing season. As summer approaches, the stock migrates to even higher altitudes. At the end of the growing season (September/October), when winter returns, sheep and goats are brought back to the lower ranges from the high altitude areas. The age-old practice of manuring fields during October in the lower ranges is still practiced.



11.2.5 Cash crops farming

Ways to increase the sustainable productivity and carrying capacity of mountain farming systems need to be explored to improve the livelihoods of marginal mountain households (Partap, 1998). Mountain agriculture is shifting from traditional cereal crop farming to high-value cash crops such as apples, almonds, pear, peaches, plums, cherries and off-season vegetables.

11.3 Challenges and constraints for sustainable mountain agriculture

Mountain agriculture has some inherent constraints including remoteness, inaccessibility, marginality and fragility in terms of moisture stress, poor soil conditions and a short growing season. Socio-economic constraints are smallholdings; poor productivity, production management, post-production management and marketing networks; labour shortages; and lack of entrepreneurship. Constraints in horticulture are poor orchard management practices, low quality of planting material, seeds and other inputs, and limited access to extension services and marketing. Because of a lack of regular markets and reliable marketing in these areas, it is too risky to diversify into high-value crops. Livestock fodder problems in the hills are more acute than those of human food. Most of the fodder and grazing areas have been infested by non-palatable invasive species, such as lantana, eupatorium and congress grass. Himalayan farmers may be facing fodder shortages of up to 70 percent.

11.3.1 Challenges

- ◆ Undulating topography, small fragmented and scattered landholdings, with soils prone to erosion due to sloping lands and heavy migratory grazing.

- ◆ The land from valleys to hilltops is inaccessible, and the infrastructure, communication, mobility and interrelated facilities are obstructed by physical, climate, ecological and socio-economic factors.
- ◆ Despite sufficient water resources in hilly areas, irrigation facilities are scant so the agriculture is mostly rain dependent.
- ◆ The shortage of energy and scarcity of labour, especially women and child labour that constitute 75 to 80 percent of family labour, has become a serious constraint due to their involvement in other businesses.
- ◆ In some regions, monkeys, wild pigs, other stray animals and birds, along with reduction in cultivable land due to housing construction and land use for non-agriculture purposes have become serious threats to agriculture.
- ◆ Natural hazards such as cloudbursts, hailstorms, floods, epidemic diseases, insects and erratic monsoons have endangered single-commodity agriculture.

11.3.2 Constraints

Constraints for agricultural production in the region can be grouped into five broad categories:

- 1 climatic,
- 2 infrastructure,
- 3 biophysical,
- 4 management and
- 5 socio-economic.

Climatic constraints include high rainfall and humidity, low temperatures during winter, low light intensity and radiation, floods and seasonal drought. High rainfall and humidity not only create favourable environments for pests, diseases and weeds but also cause problems in drying, storage and haymaking. High rainfall and cloudy weather reduce the total hours of sun essential for food production. Low temperatures for a considerable period during winter, particularly in hilly regions, limit the time available for crop production, therefore limiting multiple cropping. Landslides and landslips threaten roads/highways, villages and agricultural lands.

Infrastructure constraints include the lack of road, transport and communication facilities, inadequate irrigated areas, lack of post-harvest facilities and marketing. Management constraints include extension gaps; poor motivation and awareness; lack of farmer incentives, non-assurance of minimum price, lack of availability of inputs, lack of credit facilities and

Table 11.4 List of Future Smart Food in the mountain areas of India

Name of Future Smart Food (local name)	Major regions/districts/provinces	Category/classification 1) non-timber product; 2) minor crops; 3) main medicinal plants-pls select	Type of crops (e.g. cereal; tubes, roots; vegetable; fruits, etc)	Nutrients	Altitude (range)	Latitude (range)	Longitude (range)	Soil type	Min temperature (average)	Maximum temperature (average)	Rainfall	Crop grown period
1 Seabuckthorn (<i>Hippophae rhamnoides</i>) (In Jammu and Kashmir Seabuckthorn is known as Tsermang; the fruits are Tsestalullu)	Leh and Kargil districts of Ladakh, Lahaul – Spiti, parts of Kinnur and Chamba, districts of H.P. and Uttarakashi, Rudraprayag and Chamoli and pitho ragarh district of Uttra- khand	2	Fruit	The leaves, berries and seeds of Seabuckthorn have high nutritional and medicinal value and are excellent source of vitamins C, B, B2, E, F, K, and P, provitamin A, sugars and organic acids. High content of vitamin C and E and other bioactive substances makes it a food industry	2 000–3 600 m amsl	34° 10' N–34° 30' N	76° 13' E–76° 40' E	well drained, light to medium sandy loam, pH between 6-7 is optimum	Up to 40°C	30–40°C	Minimum 400 mm	MAY–SEP
2 Wild pear (<i>Pyrus pashia</i>) (Tangi in Kashmiri, Kainth in H.P. and Punjab)	Parts of J&K, Himachal Pradesh, Uttrakhand, Khasi and Jaintia hills of Meghalaya	2	Fruit	chlorogenic acids flavan-3-ols, arbutin, alkaloids, glycosides, flavonoids, steroids, saponins and tannins	700–2 600 m amsl	32° 17' N–36° 58' N	73° 26' E–80° 13' E	Well drained sandy loam soil	-10°C	35°C	750–1 500 mm	MAR–JAN
3 Cranberry bush (<i>Viburnum grandiflorum</i>) (Kulmanch/ kulem in Kashmir)	J&K, North Indian hills (Lahul), Sikkim etc.	2	Fruit	Antioxidants and Vitamin C. also has medicinal benefits	2 100–3 600 m amsl	34° 5' N–34° 30' N	74° 5' E–74° 20' E	Deep rich loamy soil	-12°C	36°C	500–1 000 mm	FEB–SEP

Table 11.4 List of Future Smart Food in the mountain areas of India (*continued*)

Name of Future Smart Food (local name)	Major regions/districts/provinces	Category/classification 1) non-timber product; 2) minor crops; 3) main medicinal plants-pls select	Type of crops (e.g. cereal; tubes, roots; vegetable; fruits, etc)	Nutrients	Altitude (range)	Latitude (range)	Longitude (range)	Soil type	Min temperature (average)	Maximum temperature (average)	Rainfall	Crop grown period
4 <i>Passiflora edulis</i> (Passion fruit)	Munnar and Waynad of Kerala, Nilgiri hills and KodaiKanal of Tamil Nadu, Kodagu (Coorg) region of Karnataka and parts of Mizoram, Nagaland, Manipur and Sikkim	2	Fruit	Sugars, Vitamin A (1 300–2 500 IU/100 g pulp), Vitamin C (30–50 mg/100 g pulp) and minerals such as Na, Mg, S and chlorides	800–1 500 m amsl	25° 47' N–27° 10' N	89° 45' E–92° 47' E	light to heavy sandy loams, of medium texture pH of 6.5 to 7.5	10°C	35°C	100–200 mm	AUG–DEC and MAR–MAY
5 <i>Amaranthus tricolor</i> (Amaranth)	Jammu and Kashmir, Himachal Pradesh, Uttarakhand, Sikkim, Assam, Meghalaya, Arunachal Pradesh, Nagaland, Tripura, Jharkhand, Chattisgarh, Maharashtra, Gujarat, Orissa, Karnataka, Kerala and Tamil Nadu	2	Vegetable	14.5–16.0% crude protein, source of iron and beta carotene, amino acids. Amaranth has compounds with various health benefits, which are mostly present in the oil extracted from the seeds. which have properties related to enhancing the immunity system, protection against cancer, prevention against oxidation, control serum lipid levels, decrease pain and inflammation	Up to 3 200 m amsl	24° 23' N–25° 42' N	70° 7' E–92° 32' E	Fertile loamy soil, pH of 5.5 to 7.5	4°C	35°C	750–2 500 mm	APR–MAY, MAY–JUN and SEP–OCT

Table 11.4 List of Future Smart Food in the mountain areas of India (*continued*)

Name of Future Smart Food (local name)	Major regions/districts/provinces	Category/classification 1) non-timber product; 2) minor crops; 3) main medicinal plants-pls select	Type of crops (e.g. cereal; tubes, roots; vegetable; fruits, etc)	Nutrients	Altitude (range)	Latitude (range)	Longitude (range)	Soil type	Min temperature (average)	Maximum temperature (average)	Rainfall	Crop grown period
6 Saffron (<i>Crocus sativus</i> <i>Kashmi-rianus</i>)	Jammu and Kashmir, Himachal Pradesh	2	Vegetable	Calories 310, total fat 6 g, proteins 11 g, cholesterol 0 mg, sodium 148 mg, potassium 1 724 mg, total carbohydrate 65 g, dietary fiber 3.9, vitamin A, C, D and B-6, calcium, iron	1 200–2 500 m amsl	32° 17' N–36° 58' N	73° 26' E–80° 30' E	Friable, loose, low density, well watered, clay calcarerious soils	-10°C	35°C	1 000–1 500 mm	AUG–NOV
7 <i>Atropa accuminata</i> (jala kafal/ Indian Beladona)	Jammu and Kashmir, Himachal Pradesh	3	Root	Alkaloids like atropine, scopolamine	1 800–3 200 m amsl	33° 15' 10" N–33° 30' 10" N	76° 2' 10" E–76° 25' 15" E	Moist sandy loam soil	-5°C	30°C	1 000–2 500 mm	JUN–SEP
8 <i>Fagopyrum esculentum</i> (Buckwheat)	J&K, Sikkim, Arunachal Pradesh, Meghalaya etc.	2	Cereal	rich source of protein and carbohydrate while crude fat, fiber and minerals content high lysine, vitamin B1 and B2	2 000–4 500 m amsl	31° 44' 57" N–32° 59' 57" N	76° 46' 29" E–80° 41' 34" E	Well drained sandy loam soil	-30°C	25°C	1 500–2 500 mm	JUL–OCT

Table 11.4 List of Future Smart Food in the mountain areas of India (*continued*)

Name of Future Smart Food (local name)	Major regions/districts/provinces	Category/classification 1) non-timber product; 2) minor crops; 3) main medicinal plants-pls select	Type of crops (e.g. cereal; tubes, roots; vegetable; fruits, etc)	Nutrients	Altitude (range)	Latitude (range)	Longitude (range)	Soil type	Min temperature (average)	Maximum temperature (average)	Rainfall	Crop grown period
9 <i>Bunium persicum</i> (kala zeera)	Jammu and Kashmir, Himachal Pradesh, uttrakhand	2	Spice	Essential oils, rich in terpenoids and phenylpropanoids, polyene and phototoxic furanocoumarins	1 800–3 500 m amsl	33° 17' N–36° 58' N	76° 2' 10" E–76° 25' 15" E	Well drained sandy loam to clay loam soils with good organic matter	-5°C	30°C	1 000–1 500 mm	APR–JUL
10 <i>Tanacetum dolicho-phyllum</i> (lidd guggli)	Jammu and Kashmir, uttrakhand	3	Leaves, flowers and root	transsabinyl acetate (43.2%) and transsabinol (12.7%)	2 000–3 600 m amsl	33° 15' 10" N–33° 30' 10" N	76° 2' 10" E–76° 25' 15" E	Moist sandy loam soil well drained	-2°C	30°C	1 000–1 500 mm	JUN–SEP

ineffective coordination between various departments connected with agricultural development.

Socio-economic constraints are ignorance of farmers regarding techniques, poor motivation, the lack of risk

taking capacity of poor farmers and large-scale land fragmentation (Borthakur, 1992). Future Smart Food (FSF) and area-specific foods play a pivotal role in the development of mountain agriculture. A list of FSF grown in India can be found in Table 11.4.

11.4 Opportunities for mountain agriculture development to address Zero Hunger and poverty reduction

11.4.1 Agriculture diversification and sustainable intensification

Agricultural diversification into fruit and vegetable crops in Himachal Pradesh is spreading to many new areas in the low and mid-hills. Microlevel experiences have shown that diversification with high-value crops is not only economically beneficial but ameliorates stress on the natural resource base (Chand, 1996).

Arunachal Pradesh, with its mountains and hill terrains, has negligible arable flat land that is suitable for settled cultivation. The state's Agriculture Department estimated that about 5 percent of the total geographical area of the state is used for agriculture. The 1980–1981 agricultural census reported that the total land under various agricultural land-use categories was about 4 percent, or 335 732 hectares. Two distinctly different agricultural practices: *jhum* or shifting cultivation, and permanent or settled cultivation occur in the state. *Jhum* cultivation is practiced almost universally by local tribes due to the inhospitable nature of hilly terrain. Settled cultivation is practiced in the foothills on an insignificant proportion of the total land area. The tropical humid forest, high rainfall and low land-man-land ratio are conducive to the practice of shifting cultivation. The two main cropping patterns in Arunachal Pradesh are mono and mixed cropping. Monocropping is practiced only in settled areas, whereas mixed cropping is practiced in both settled and *jhum* areas. Various strategies are being used to improve the socio-economic condition of people living in these areas.

A Piggery development

Pork is the preferred meat for many consumers in north-eastern India. In 2004–2005, Nagaland State recorded the slaughter of 386 000 pigs with a net yield of 29 350 metric tonnes of pork (Basic Animal Husbandry Statistics, Department of Animal Husbandry and Dairy, Ministry of Agriculture, GOI). Nagaland State, however, still depends heavily on supplies from outside the state to fulfil its pork demand. A market survey undertaken in district headquarters indicated that pigs sourced from outside the state and slaughtered for pork account for nearly 10.26 metric tonnes with a monetary value of 925 million rupees per annum.

B Dairy development

Production of quality heifers and the introduction of superior cattle by involving groups such as dairy farmers, the milk union, civil society and self-help groups have focused on the 'White Revolution', which has boosted the dairy sector to make India the world's biggest milk producer. The entire operation requires processing, chilling, packaging and organized marketing for maximum remuneration for farmers. For effective implementation of the Dairy Entrepreneurship Development Scheme of the National Bank for Agriculture and Rural Development (NABARD), state banks need to be more proactive.

C Poultry development

Production of enough low-input technology (LIT) birds from the Department Poultry Farms, which will be linked to satellite poultry farms at the farm level so that farmers/entrepreneurs can take up Finisher Units or Egg Production Units as per the capacity of the farmers.

D Small animal development

Goats and rabbits are also popular among farmers, particularly women. Therefore, the production of superior germplasm of goats and rabbits from the Department of Animal Husbandry and Dairy farms will be given priority to enable farmers to set up medium-sized goat and rabbit farms for commercial purposes.

E Development of indigenous animals

North-eastern India is home to a variety of indigenous animals such as *Mithun*, *Phre*, *Thotho* cattle, swamp buffalo, *desi* pig (*Votho/Suwo*), *desi* poultry and long-haired goats which can be used for both for meat and draught purposes. The management of these animals needs to be improved to enhance production and productivity for self-sufficiency.

F Bamboo development vision

Bamboo development in Nagaland took place in four phases:

- 1 Inception, from 2007 to 2012, focused on augmenting existing resources, commoditization of bamboo with existing and other viable industries based on the available bamboo raw materials, building infrastructures and institutional frame works;
- 2 Growth, from 2013 to 2017, encompassed new applications and augmented the developments of the first phase;

- 3 Consolidation, 2018 to 2020; Targeting of the maximum generation of revenue from both natural and captive resources from 2020 to 2025, This phase will involve an increased demand for raw bamboo, with further plantations established in the anticipation of a flourishing bamboo industry. A substantial percentage of India's total value of bamboo production will come from the Nagaland region, comprising about 20 percent of global production value.

G Agriculture crops

Through production of fruits, vegetables and other horticulture products, the north-eastern region could have a comparative advantage by establishing small-scale processing units for the local market, which would also create rural employment. The region produces many spices such as chillies, ginger and turmeric. Rubber and bamboo are important non-wood forest products offering investment opportunities in the region. Tripura is the chief production hub, while other rubber producing states are Mizoram and Assam. Globally, India ranks third in production and fourth in consumption for rubber.

H Horticulture Mission for the North East and Himalayan (HMNEH)

HMNEH covers all the North-Eastern and North-Western Region Himalayan states. From 2010 to 2011, 3 999 million rupees was distributed by HMNEH of which 2 699 million rupees went to the north-eastern states and 1 299 million rupees to North-Western states. By implementing the Technology Mission (a Ministry of Agriculture project) for horticultural crops in the North-Eastern Region, the Indian government has made a significant contribution to area expansion, crop production, productivity, marketing, value addition and post-harvest management.

11.4.2 Agroprocessing activities for agriculture products

At present, the food processing industry is mainly operated on a small scale in mountain areas. In 2009, in north-eastern India, 85 units received licenses under the Fruit Products Order (FPO) Act, of which only 32 are functional units (Ministry of Small-Scale Industries, 2009). The number of food processing industries varies from year to year in north-eastern India.

Ginger is an important cash crop in north-eastern India. During the primary processing of ginger crops, farmers' incomes increase by 42.8 percent per kg. Banana,

pineapple and orange are the most important fruit crops, accounting for about 60 percent of the area and 66 percent of the production. Other important crops include lychee in Tripura and Assam; apples in Arunachal Pradesh; passion fruit in Nagaland, Mizoram and Manipur; cashew in Assam and Tripura; and coconut in Assam, Tripura and Nagaland. Surplus produce is either exported in its raw state or processed. Processing involves service sectors such as transportation, restaurants, packaging, advertising and marketing, which creates employment and income-generating opportunities.

11.4.3 Value-addition measures and activities for agriculture products

A Globally Important Agriculture Heritage Systems (GIAHS): In India, there are three GIAHS sites which are located in:

- ◆ **Koraput, Odisha:** This region is best suited to crops such as paddy, millet, pulses, oilseed and vegetables.
- ◆ **Kashmir Valley, Pampore:** The Saffron Heritage Site of Kashmir in India is best suited to grain crops such as maize, rice, rajmash/lentils, fruit, vegetable crops and pulses.
- ◆ **Kuttanad:** This delta region of about 900 km² is on the west coast of Kerala and is the only place in India where rice is cultivated below sea level (backwater paddy cultivation).

B Procurement programmes

Type of project	Scope of project
Concentrated feed and feed block manufacturing plants at Bajali, Barpeta and Sonapur, Kamrup (M)	Install appropriate plant and machinery, source raw material, ensure water disposal, establish store facilities and create marketing infrastructure
Organic milk production across all districts of Assam	Procure and manage livestock, provide source for organic fodder, establish store facilities and refrigeration systems
Organic fodder production across all districts of Assam	Install appropriate plant and machinery, source raw material, ensure water disposal, create storage facilities and create marketing infrastructure

Type of project	Scope of project
Biogas plants across all dairy cooperatives in Assam	Choose appropriate technology for production of biogas from cattle excreta and biomass for power generation conforming to the standard norms approved by the Ministry for Non-Renewable Energy
Setting up broiler parent breeding farms in Assam	Opportunity for private-sector investment in setting up broiler parent breeding farms
Manufacture of bamboo mat board, bamboo mat corrugated sheets and bamboo floor boards	Investors are expected to install appropriate plant and machinery, source raw material, ensure waste disposal, establish storage facilities and create marketing infrastructure

C E-Agriculture initiatives in India

A research report presented at the Global Information and Communication Technology (ICT) Summit of 2004 indicated that 45 percent of the world's ICT projects were implemented in India (Manzar, 2004). There are four major types of e-agriculture initiatives in India:

- 1 **Web portals:** aAQUA, KISSAN Kerala, TNAUAgriTech Portal, AGRISNET, DACNET, e-Krishi, ASHA, India Development Gateway portal, Agropedia, AGMARKNET, ITC-e-Choupal, IFFCO Agri-Portal, iKissan, Krishi Sandesh, etc.
- 2 **Knowledge centres/tele-centres:** Village Knowledge Centres (VKCs) of M.S. Swaminathan Research Foundation (MSSRF) (Senthilkumaran, 2011) and others; Village Resource Centres (VRCs) of the Indian Space Research Organization (ISRO); Community Information Centres etc.
- 3 **Telephony/mobile telephony (m-agriculture initiatives):** Farmers Call Centre (Kissan Call Centre), IFFCO Kisan Sanchar Limited (Mittal *et al.*, 2010), Mobile Advisory Services by Krishi Vigyan Kendras (KVKs) of the Indian Council of Agricultural Research (ICAR), etc.
- 4 **Hybrid projects (ICTs with traditional extension elements):** e-Sagu, Digital Green, e-AgriKiosk, e-Villages, Knowledge Share Centres, etc.

11.4.4 Social protection measures targeting mountain people

A The scheme for technology upgrade, establishment and modernization of food processing industries

The scheme is the signature initiative of the Central Ministry of Food Processing Industries. It covers setting up technology upgrade/modernisation/establishment of food processing industries for fruits and vegetables, milk products, coconut, mushrooms, etc. The government in north-eastern India is trying to implement this scheme, but the results have not been satisfactory due to excessive formal rules and very low approval rates.

B Mega Food Park scheme, Government of India

This scheme, revised under 11th Five Year Plan, aims to provide adequate infrastructure for food processing along the value chain from farm to market. The scheme provides typically grants of 50 percent of the capital cost excluding land, subject to a ceiling of 500 million rupees. However, in north-eastern India, the grant is 75 percent. The scheme covers 20.23 hectares of total land supported by a network of six Primary Processing Centres (PPC) and 19 Collection Centres in the North-Eastern Region, with a Central Processing Centre at Nathkuchi, Tihu, Assam.

C Scheme for Cold Chain, Value Addition and Preservation Infrastructure, Government of India

This scheme provides grant-in-aid for 50 percent of the total cost (plant and machinery plus technical civil work) in general areas, or 75 percent in the north-eastern region

11.4.5 Other initiatives

- ◆ Subsidies to promote technology such as using drones for development of agriculture in mountain areas of India.
- ◆ **One person one plant**
In 2016, in a similar approach to the Save Horticulture Mission, mountain people must be involved in fruit and herb planting. That is, each person should plant at least one plant on special occasions such as birthdays, marriage ceremonies and festivals. This type of initiative is an effort to help solve problems related to soil erosion and climate change.
- ◆ Use of sensors for tracking animal movements in mountain areas.

11.5 Country experience

11.5.1 Good agricultural practices on sustainable and integrated farming in mountain areas

Traditional farming systems	Present-day farming systems including development interventions
A Enhanced use intensity/input absorption capacity of land	
Small-scale, location-specific, community-oriented/ supported resource amendments using ethno-engineering measures; terracing/drainage management, community irrigation, agroforestry, etc.	Weakened traditional measures, supplemented and substituted with selected, larger-scale resource upgrades, for example, irrigation, infrastructure and watershed development, and use of modern science and technology and public subsidy.
B Usage and management of low use capability lands	
Diversified, land-based activities; involvement in agronomic measures for low land intensity and low-input regimes (local and affordable); and integration of low-intensity and high-intensity land uses (based on annual-perennial plants, crop-fallow rotations, indigenous agroforestry, resource-use regulations and conservation).	Driven by increased population and land shortage, and rapid increase in indiscriminate intensification of land use; sectorally separated production programmes; high-intensity uses promoted through new technology inputs/incentives or subsidies; and limited conservation-oriented initiatives (forests/pastures/watersheds).
C Options to harness diversity and niche markets	
Agronomy-diversified cropping, focus on multiple use species; complement cropping – with livestock/ forestry/horticulture; emphasis on biomass in choice of land-use and cropping patterns, with location-specific choices; and harnessing of potential niches for tradable surplus.	Reduced diversification and narrowed focus on cropping driven by: (1) subsistence needs (e.g. food crops); (2) commercialization (horticulture) (3) sectorally segregated programmes and their support systems (research and development, input supplies, crop marketing), focus on selected attributes (e.g. monoculture).
D Manage isolation, external links and demand pressure	
Living with relative inaccessibility and isolation from mainstream markets; scarcity period–external dependence through migration for sources of income; and insignificant surpluses. Subsistence strategies focused on diversification and linkages of land-based activities; flexibility in scale, operations, or input use; local renewable resources, recycling or inputs/products, self-provisioning; release of periodic/seasonal pressure by migration creating a remittance economy; and emphasis on managing demand.	Reduced risk of isolation due to improved physical and market linkages; integration of mountain economy with other systems; and highly uneven but improved opportunities for relaxing internal constraints through technology. Reduced sole dependence on local resources, and decline of resource regeneration and recycling practices. Increased dependency on subsistence of external resources; encourage perpetual growth of pressure on fragile resources; and indifference to local self-help initiative.

Source: Jodha, 2009

11.5.2 Policy measures and initiatives for sustainable and inclusive mountain development

A Poverty alleviation: gaps and fresh opportunities

Global initiatives such as the Millennium Development Goals (MDGs), Millennium Ecosystem Assessment, Global Climate Change and Economic Globalization provide the broad framework for addressing poverty, livelihoods and sustainability issues in mountain areas. This is an important first step toward linking location-specific activities and products to markets, which can help to generate opportunities and gains from exchange including equitable highland-lowland links (Partap, 1998). To respond to fragility, geographically based constraints

of steep slopes and high cost of infrastructure, efforts should focus on location-specific components to help with access such as rural roads, donkey tracks, gravity ropeways and suspension bridges.

B Handling social marginality

Accelerate the processes of social mobilization and protection of indigenous people's rights, and increase awareness and responses to concerns of marginal groups using bottom-up approaches.

C Productive use of fragile slopes and marginal lands

Mountain landscapes have the potential for specific industries such as mountain herbs, grazing and hardy crops. Some micro-enterprises such as honeybee,

small-scale poultry and stall-fed goat keeping can be undertaken on these lands. The production potential of such land can be improved with the provision of irrigation through local water harvesting and links to product markets (for fair product prices) using rural roads, etc.

D Diversified farming systems

Traditionally, mountain farmers have harnessed gains through various spatial and temporal combinations of crops and other activities linked to livestock, farm forestry, etc.

E Equitable highland – lowland economic links

The inequitable links between highland and lowland areas are responsible for the flow of underpriced mountain resources and products to the low lands. Improved accessibility would help to create equity. In addition, the public policies directed to local physical and institutional infrastructure and human capacity building are equally important to ensure equitable links and their benefits to mountain producers (Jodha, 2000).

F Globalization context: risks and opportunities

There are visible incompatibilities between mountain specificities (such as appropriateness of diversified production systems) and globalization processes (such as focused selectivity and narrow specialization). To handle these incompatibilities, efforts are needed to build local capabilities (Jodha, 2005).

G Gender involvement for new horizons

Hill women are the most important food producers and have great knowledge, experience and flexibility in cropping practices, while the hill men tend to concentrate on the commercial potential of timber and other goods. Fifteen women in Yagrung Village of the Pashigat District of Arunachal Pradesh have reshaped their lives by forming self-help groups. They receive training on the cultivation of various crops and participate in different *melas* or farmers' fairs in north-eastern states. In addition, the shift by hill farmers toward organic farming, since 2001 in several Himalayan states, is having an impressive impact on quality of produce. In a nationwide survey of organic farmers, Partap and Vaidya (2009) found several factors that are encouraging farmers to change to organic farming, including improved soil quality and fertility, reduced dependence on external sources, increased productivity and reduced health hazards and pesticide use.

11.6 Case studies

In Jammu and Kashmir, the state government is promoting hill horticulture by introducing schemes such as the Rural Appraisal for Livelihood Systems, Seed and Planting Material Production Drive and Rashtriya Kisan Vikas Yojna (an assistance scheme for promoting annual growth in the agricultural sector).

A Improved livelihoods through fruit farming

This success story from several districts of Himachal Pradesh illustrates the promotion of fruit farming on marginal farmlands in the hills. Abdul Ahad Mir of Gousoo Village, Srinagar received assistance from the Horticulture Mission to cultivate strawberries on 0.05 hectare of land. The farmer emerged as a leading strawberry grower, such that other farmers in his village have adopted strawberry cultivation, which now covers about 16.2 hectares of land. The annual income of this farmer per acre is about 5 lakh (a lakh is one hundred thousand rupees) per hectare, compared with 20 000 to 25 000 per hectare prior to diversification. Gousoo is now known as the strawberry village.



B Forest floor farming of cardamom in the forests of Sikkim

The ethnic mountain farming communities of Sikkim chose the wild, high-value spice cardamom as a source of income. The cardamom is farmed under the forest floor similar to any perennial crop. Almost 75 percent of farmers in north Sikkim have replaced food grain agriculture on their farmlands with cardamom, which sustains 40 to 88 percent of their livelihoods.

C Developing the concept of economic forestry: A success story in Ladakh Region

The seabuckthorn success story is an outstanding example of how development approaches in the hills can combine horticulture and forestry to promote an economically and ecologically productive hill farm economy. Local farmers have strong economic reasons for maintaining seabuckthorn forests and government institutions have long-term strategic ecological interests in promoting them. The Leh Berry Brand name is a good example of a success story of seabuckthorn for the Himalayan farmers of Ladakh as the juices of the berries have found many good markets.



11.7 Strategic considerations and suggestions

There is a need for a well-defined policy to increase economic growth and create job opportunities for unemployed rural people through agriculture and allied sectors. The major constraints are low productivity levels, capital inadequacy, lack of infrastructure support, high production costs and demand-side constraints. The lack of storage and processing facilities, low-value addition and unfavourable returns on agricultural commodities severely affects the agricultural industry and encourages migration from rural areas to urban centres. The following strategies are recommended for the development of mountain areas:

◆ The top priority is to increase the income of farmers:

Hill farming in the northeast largely uses *jhum* cultivation, which is becoming less productive as it has long been the cause of erosion and forest regression. The problem needs to be tackled sensitively as *jhum* cultivation is the traditional way of farming in certain areas. ICAR has evolved a three-tier hill farming package combining forestry, horticulture or tree farming, and terraced cultivation as one moves down the hills. *Jhum* improvement is

advocated by others and can be carried further through appropriate research and development. Nagaland has pioneered an excellent method of upgrading *jhum* by incorporating an increasing component of agroforestry through assisted tree planting of selected fast-growing timber with economic value and breeding plant material for widespread propagation.

- ◆ **Location-specific strategy development:** Formulate an area-specific strategy by considering agronomic, climatic and socio-economic practices as well as resource worthiness of farmers. Special emphasis should be put on introducing newly developed hybrid yield variety seeds and improved planting material, along with the adoption of new technologies and mechanized farming.
- ◆ **Transfer of location-specific technology:** Introduce innovative and decentralized institutional change to create extension systems that are responsible and accountable.
- ◆ **Input supply:** Provide adequate and timely supply of inputs such as seed, fertilizers, pesticides, and agritools and implements, with credit provided by the government and other institutions at reasonable rates to the farmers. As far as possible, encourage the use of organic manure/compost to avoid the ill-effects of inorganic fertilizers.
- ◆ **Facilitate private investment in agriculture:** Encourage participation in private enterprises to establish agro-based industries. NABARD will need to play a major role in channelling investments.
- ◆ **People participation:** Encourage the formation of self-help groups and village committees at different levels to maintain and manage assets such as irrigation channels, terraces, market sheds, etc.
- ◆ **Marketing infrastructure:** Emphasize the development of marketing infrastructure and techniques to preserve, store and transport produce with a view to reducing post-harvest losses and ensuring better grower return.
- ◆ **Food processing:** Set up food processing units in production areas to reduce post-harvest waste.
- ◆ **Use of information technology:** Strengthen the agricultural sector database for greater reliability of estimates and forecasting to help in the planning and policy making process.
- ◆ **Flood and drought management:** Review the National Crop Insurance Scheme to facilitate its introduction into the northeastern states of India.

11.7.1 Policies, measures and governance

A Hill Area Development Programme (HADP)

The main objectives of this programme are ecological preservation and restoration with an emphasis on the preservation of biodiversity and rejuvenation of hill ecology.

B Western Ghats Development Programme (WGDP, 1974)

The programme adopts an integrated watershed development approach in the Western Ghats area, prioritizing ecological development and restoration, along with meeting the basic needs of food, fuel and fodder.

C National Policy for the Integrated Development of the Himalayas (1992)

An expert group was set up by the Planning Commission to formulate a policy for the development of the Himalayas in the following areas:

- ◆ Environment and forests
- ◆ Agriculture and allied activities
- ◆ Industry and industrial infrastructure
- ◆ Social sectors including health and family welfare
- ◆ Transport, communications and tourism
- ◆ Energy including non-conventional energy, science and technology

D Ministry of Environment and Forests notification on the restriction of certain activities in specified areas of the Aravalli Range (1992)

- 1 Issued under the Environment (Protection) Act, 1986, the notification restricts certain activities that would cause environmental degradation in the Aravallis.
- 2 Activities that are prohibited include new industry and mining in sanctuaries and national parks; and deforestation.
- 3 Environmental impact assessments and management plans are required to carry out any of the restricted activities in this region.

E Notification on the protection and improvement of the quality of the environment in the Himalayas (2001)

- 1 Issued by the Ministry of Environment and Forests under the Environment (Protection) Act 1986, specifically for environmental protection in the Himalayan states.

- 2 Activities undertaken by the Botanical Survey of India (BSI) include:

- a) Survey of plant resources
- b) Taxonomic studies of all flora
- c) Creation of a list of endangered species
- d) Preparation of national database of herbs.

F Activities undertaken by the Zoological Survey of India (ZSI)

The primary objectives of the ZSI are:

- a) Explore and survey faunal resources
- b) Undertake taxonomic studies
- c) Conduct status survey of endangered species
- d) Publish assessments of fauna of India
- e) Maintain and develop national zoological collections.

G Activities undertaken by the Forest Survey

The Forest Survey of India (FSI) assesses the forest resources of India using parameters such as forest cover, growing stock, annual increment, species composition and biodiversity.

H Activities undertaken by the Indian Meteorological Department (IMD)

The mandate of the IMD includes:

- a) Taking meteorological observations and providing meteorological statistics
- b) Warning against adverse weather phenomena such as cyclones and heavy rains
- c) Detecting and locating earthquakes and evaluating seismic sources.

I Integrated Watershed Management Programme (IWMP)

The IWMP, a flagship programme of the Government of India under Ministry of Rural Development, Department of Land Resources. Its main objective is to restore ecological balance by harnessing, conserving and developing degraded natural resources. The State Level Nodal Agency (SLNA) implements IWMP under the Common Guideline for Watershed Development, 2008.

11.7.2 Interventions

A Promoting integrated watershed development and alternative livelihood opportunities

In India, some of the economically weaker states are treated as Special Category States, including Jammu and Kashmir, Himachal Pradesh, Uttaranchal, Sikkim, Manipur, Meghalaya, Nagaland, Tripura, Arunachal Pradesh and Mizoram (Ninth Five-Year Plan, 1997–2002). Special Central Assistance is given to these cases; 90 percent in the form of a grants and 10 percent as loans, compared with 30 percent and 70 percent, respectively, for the other states (Planning Commission, 1999). Since 1974, two programmes: HADP and WGDP, have focused on mountain areas. The primary objectives of these programmes are the preservation of biodiversity and rejuvenation of hill ecology (Planning Commission, 2001). HADP has been implemented in designated hill areas in Uttar Pradesh, Assam, Tamil Nadu and West Bengal. The areas covered by the WGDP include parts of Maharashtra, Goa, Karnataka, Kerala and Tamil Nadu. Under these programmes Special Central Assistance supplements state government efforts in the development of ecologically fragile regions (Planning Commission, 2001a). The assistance is apportioned between the designated hill districts and Western Ghats areas in the ratio 5:1.

The WGDP adopts an integrated approach to develop identified watersheds. Some of the main activities that have been undertaken in the Western Ghats under this scheme include:

- ◆ Programmes for soil conservation on watershed basis (Planning Commission, 2001).
- ◆ Land-development activities such as levelling, terracing, contour bunding and water erosion control structures including check dams.
- ◆ The Western Ghats region has tremendous potential for cultivating horticultural crops, with about 3.6 lakh hectares of cultivable wasteland (Planning Commission, 2001).
- ◆ Programmes for afforestation, regeneration of degraded forestlands, and fodder and pasture-land development schemes have been implemented.
- ◆ Diversification of cropping patterns to improve crop productivity by subsidising small and marginal farmers for agricultural implements, power sprayers, sprinklers, etc.
- ◆ Alternative livelihoods such as animal husbandry, dairy development and tourism.

B Generating and strengthening knowledge about the ecology and sustainable development of mountain ecosystems

Established scientific and research institutions, such as the BSI, ZSI and FSI undertake comprehensive assessments of flora, fauna and forest resources in India. To date, 65 percent of India's area has been surveyed. The BSI has collected three million herbarium specimens. From 1987 to 1997, the BSI discovered 106 new species and the ZSI discovered 759 new species (Ninth Five-Year Plan, 1997 to 2002). Every two years, the FSI prepares a comprehensive State Forest Report, including a National Forest Vegetation Map. Meteorological analysis, climate monitoring and vulnerability assessments to natural disasters are undertaken by the IMD. The IMD has also been undertaking ozone measurements since 1928.

C Nagaland Beekeeping and Honey Mission (NBHM) initiatives and intervention on beekeeping

The state government of Nagaland launched the NBHM in 2007 to exclusively promote and develop beekeeping as a robust industry and to generate income to uplift the rural economy.

D Nagaland Empowerment of People through Energy Development (NEPED) hydrogen initiatives for renewable energy for rural economic development

Focusing on livelihoods and the environment, the previous phases of the NEPED, highlighted the need for energy as an essential requirement for adding value to farm produce. So NEPED was established as a specialized institution dedicated to providing renewable energy.

11.7.3 Strategies for sustainable mountain development

Areas that have been identified for promoting ecological development in hill regions under the HADP and WGDP include:

- ◆ Continuing the watershed-based approach adopted by the Western Ghats region and incorporating it in the hill areas of Assam and West Bengal.
- ◆ Adopting a participatory approach in the formulation and implementation of schemes under these two programmes by encouraging the involvement of Panchayati Raj Institutions (PRIs) and non-governmental organizations (NGOs).

- ◆ Develop technologies suited to local conditions such as farm implements for small landholdings, microhydel projects and, rainwater harvesting.
- ◆ Provide incentives to farmers for conserving the traditional gene pool of crops and livestock by promoting traditional farming practices.

PRIs play an important role by involving local populations and NGOs for informed decision-making. Traditional knowledge and skills can be applied to the development challenges faced in these hill areas. In the Approach Paper to the Tenth Five-Year Plan (Planning Commission, 2001), the government recognized the role of non-conventional energy sources in meeting the energy demands of remote and inaccessible areas, using local resources and cutting out the expensive delivery mechanisms associated with conventional energy sources.

11.8 Conclusion

- ◆ The Himalayan region is the biggest contributor to mountain agriculture in India.
- ◆ Diversification of hill agriculture will provide better choices and quality options for sustaining the livelihoods of hill farmers.
- ◆ The rights of the inhabitants of hilly areas are being fragmented and undermined through administrative policies, national environmental legislations and trade agreements.
- ◆ Water insecurity is a main poverty feature in the uplands where sloping lands dominate.
- ◆ Planners should concentrate on scientifically harnessing natural resources and, systematically exploit the strengths and opportunities of mountain areas.
- ◆ National policies should include commensurate strategies for hill agriculture research, technology and marketing. It should recommend strengthening the interdependency and synergy between agriculture sectors in terms of crops, horticulture, livestock, fisheries, forestry and the associated natural resources.

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12 Lao PDR

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12.1 Overview

12.1.1 About the country

12.1.1.1 Physical characteristics

Lao People's Democratic Republic (Lao PDR), also known as "Laos", is the only landlocked country in Southeast Asia, sharing borders with Cambodia to the south, Thailand to the west, Viet Nam to the east and China and Myanmar to the north and north-west, respectively (Figure 12.1). The country is situated between latitudes 13° 45' N and 22° 41' N and longitudes 100° 09' E and 107° 45' E, covering a total land area of 236 800 km². The country is typical of mountainous countries, with almost 90 percent of its area being steep land and with an abundance of natural resources including land, water, and forest, i.e. hardwood timber, hydropower, and minerals (coal, gypsum, tin, gold, gemstones, etc.).

Administratively, the country is divided into three regions (northern, central and southern), which are further divided into 18 provinces, including the capital Vientiane, 143 districts, and 8 643 villages. The northern region comprises eight provinces, including a new province (Xaysomboun) officially established in 2013, the central region has five provinces, and the southern region has four provinces. In terms of area, the northern region is the largest, occupying 42.8 percent of the total area, followed by the central (36.9 percent) and the southern (18.6 percent) regions.

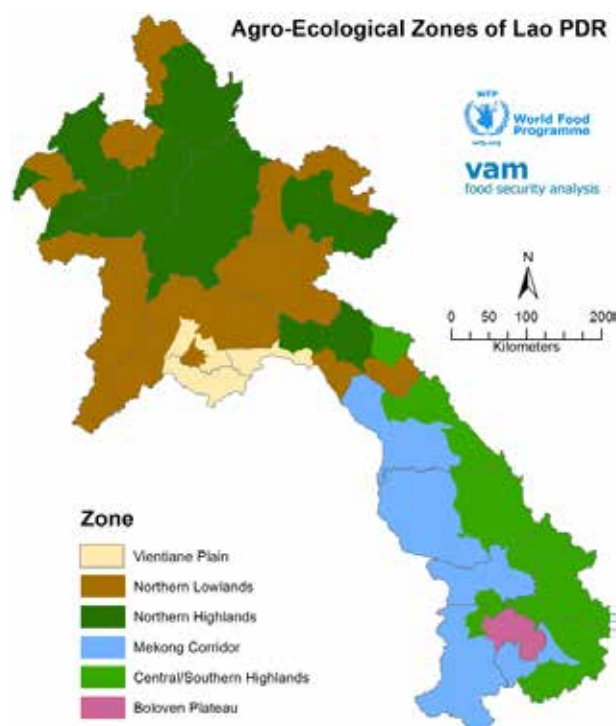
Six agro-ecological zones (AEZs) have been identified in Lao PDR: 1) Mekong Corridor (AEZ1), 2) Central-Southern Highlands (AEZ2), 3) Vientiane Plain (AEZ3), 4) Bolovan Plateau (AEZ4), 5) Northern Lowlands (AEZ5), and 6) Northern Highlands and Uplands (AEZ6) (Figure 12.1) (World Bank, 2006). Table 12.1 describes the characteristics of each zone. AEZ2, AEZ4, AEZ5 and AEZ6 are identified as mountains – about two-thirds of the total rural population reside in these zones where shifting cultivation of upland rice and livestock raising are the dominant agricultural production.

The climate of Lao PDR is seasonally tropical with a pronounced wet and dry season. The wet (monsoon rain) season starts from May and ends in October. The dry season begins in April and terminates in November, with a cool, dry season from November to February and a hot and dry season in March and April. The mean annual rainfall varies significantly, ranging from less than 1 400 mm to more than 3 000 mm. The mountainous region in the north has the lowest annual rainfall, with large areas receiving less than 1 400 mm, while the Annamite range in the east and south receives more than 2 000 mm with some areas receiving well above 3 000 mm (Figure 12.2). About 99.9 percent of the annual precipitation falls during the wet season and another 9.1 percent during the dry season (Ministry of National Resources and Environment and United Nations Environment Programme, 2012).

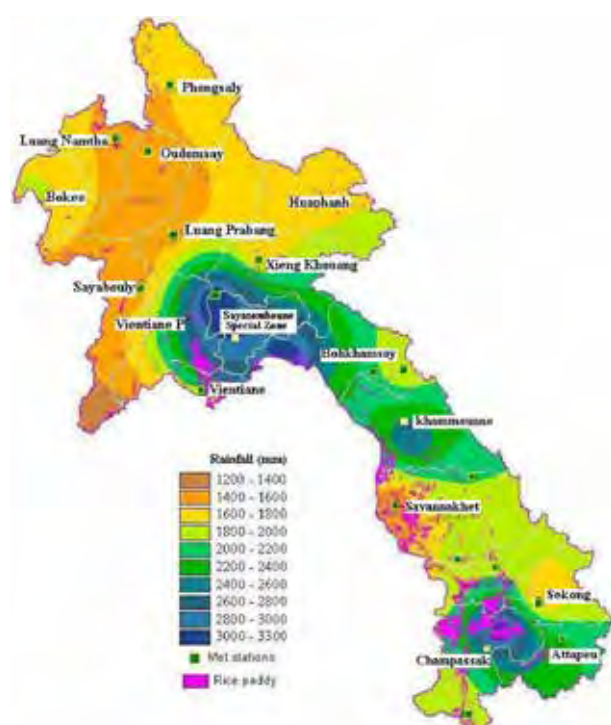
Temperatures in Lao PDR vary considerably throughout the year, and also change according to latitude and altitude. Nationally, average temperatures range from 28°C to 38°C. For the year 2006, average temperatures of the mountainous areas in the north and east and plateaus in the south were 20°C, and in the plains in the central and south were 26°C. The average temperature for the country was 26.5°C (National Statistics Center, 2007).

In Lao PDR, soil types are classified into 15 groups (FAO UNESCO, 1987): Arenosols (AR), Acrisols (AC), Alisols (AL), Cambisols (CM), Calcisols (CL), Fluvisols (FL), Ferralsols (FR), Gleysols (GL), Luvisols (LV), Leptosols (LP), Lixisols (LX), Nitisols (NT), Regosols (RG), Solonetz (SN) and Solonchacks (SC).

Acrisols soil group accounts for a total of 11.6 million ha (48.9 percent of the total area in the country). Alisols 4.4 million ha (18.8 percent); Luvisols 3.0 million ha (12.7 percent); and Cambisols 2.3 million ha (9.9 percent), respectively. The remaining soil groups amount to 1 percent or less of the total area in the country (Ministry of Agriculture and Forestry, 2017).

Figure 12.1 Agro-ecological zones of Lao PDR

Source: World Food Programme, 2011

Figure 12.2 Distribution of annual rainfall in Lao PDR

Source: Basnayake, J *et al.*, 2013

12.1.1.2 Demographics

Lao PDR is the lowest population density country (approx. 27 people/km²) in Southeast Asia after Timor-Leste and Myanmar, with a population of 6.5 million in 2015 and an annual population growth rate of 1.45 percent in recent years. The average household size declined from 5.8 in 2005 to 5.3 in 2015. The ratio of male to female is 101:100. Lao PDR is a relatively young nation with 32 percent of its population aged 0–14 years. The working-age (15–64 years) population accounts for 64 percent of the total population. The total dependency ratio, an economic burden indicator for the care (the age group between 15–64 years old) of dependents (the age group of less than 15 years and more than 64 years, has improved significantly from 77 in 2005 to 57 in 2015.

Lao PDR is rich in ethnicities and culture. There are four ethnolinguistic groups that are aggregated from 49 primary ethnic groups. The Lao-Tai ethnolinguistic group is the most prominent, accounting for 62.4 percent of the total population, followed by Mon-Khmer (23.7 percent), Hmong-Mien (9.7 percent), and Chinese-Tibetan (2.9 percent) (World Food Programme and Federal Ministry for Economic Cooperation and Development, 2013).

In terms of religion, 65 percent of the population is Buddhist with Christians making up around 2 percent. Some 31 percent consider themselves as having no religion or have a belief in animism (Lao Statistics Bureau, 2015).

Lao PDR is predominantly rural with 67 percent of its population living in rural areas (villages). About 50 percent of the country's provinces have more than 70 percent of their population living in rural areas.

Nationally, about 8 percent of the villages are considered rural without road access, which is more pronounced in the northern and southern mountainous regions (12.5 percent and 12.2 percent, respectively) compared with 4.8 percent and 0.1 percent for the central region and Vientiane, respectively.

Vientiane capital is the most urban area in the country with 78 percent of its population living in urban villages, compared with 28 percent in the northern and central regions and 27 percent in the southern region (Lao Statistics Bureau, 2015).

12.1.1.3 Economy

Lao PDR has a low–middle income economy with GDP per capita of USD 1 970 in 2015; it is one of the fastest growing economies in the East Asia and Pacific region and globally. GDP growth averaged 7.9 percent from 2011 to 2015 (industry 11.0 percent, services 8.8 percent, and agriculture 3.0 percent).

Table 12.1 Agro-Ecological Zones (AEZ) in Lao PDR

Agro-Ecological Zone (AEZ)	Landforms and land use	Rural population and density	Altitudes (m asl)	Rainfall (mm/y)	Dominant agricultural types
1 Mekong Corridor (AEZ1)	This zone covers the areas of the floodplains and riverbanks alongside the Mekong River and the lower valleys of its tributaries. The landforms are mostly flat to gently sloping. For centuries, natural forest in flat areas has been converted and used for intensive farming, particularly lowland rice, and crops for income on the sloping land.	Population: 1.5 million % rural pop: 36.1 Most densely populated AEZ	100–200	1 500–2 000	Lowland rice, gardening and livestock raising
2 Central-Southern Highlands (AEZ2)	Topography ranges from undulating to rolling hills, covering upper valleys of Mekong tributaries with most areas affected by the high rate of unexploded ordnance. The soil is acidic with low fertility, therefore, improving land productivity is essential.	Population: 300 000 % rural pop: 7.2 Fewer than 15 people/sq km	200–500	2 000–3 000	Shifting cultivation of upland rice and livestock raising
3 Vientiane Plain (AEZ3)	This zone occupies areas of high plains and lower slope terrain, dominated by rolling hills and middle upland areas. Shifting cultivation with upland rice is the most important agricultural activity followed by livestock raising. Existing natural forest needs protection from illegal encroachment.	Population: 300 000 % rural pop: 7.2 Low to medium density	500–1 000	2 500–3 000	Shifting cultivation of upland rice and livestock raising
4 Bolovan Plateau (AEZ4)	This zone covers the upper areas of the Mekong tributaries. The mainland covers are savannah, grasslands and forests and the main livelihoods are livestock and tree crops (coffee, tea, and cardamom) followed by shifting cultivation with upland rice as the main crop. This zone has encountered rapid rural development with little impact on poverty reduction.	Population: 60 000 % rural pop: 1.4 No density data	500–1 500	2 500–3 000	Tree crops, some shifting cultivation of upland rice and livestock raising
5 Northern Lowlands (AEZ5)	Landforms similar to those in AEZ 6. Shifting cultivation, cash crop production and livestock husbandry have been damaging natural forest resources. Although commercial production has improved the livelihoods of local farmers, the lack of effective soil erosion control measures has been an issue for the productivity and sustainability of existing farming systems.	Population: 1.0 million % rural pop: 24.0 Higher density than AEZ6	500–1 500	1 500–2 000	Shifting cultivation of upland rice and livestock raising
6 Northern Highlands and Uplands (AEZ6)	Steep mountainous landscape with poor accessibility and a high risk of soil erosion. Conditions are favorable for crop and animal production. Existing agriculture is under pressure to change to market-oriented systems. Unsustainable shifting cultivation practices and commercial production are threatening local natural forest resources.	Population: 1.0 million % rural pop: 24.0 Low density	1 500–2 500	1 300–2 500	Shifting cultivation of upland rice and livestock raising

Table 12.2 Five-year (2011–2015) socio-economic development performance in Lao PDR

Parameters	Fiscal years		Average 2011–15	Change
	2010/11	2014/15		
GDP growth rates (%)	8.1	7.5	7.9	–0.4
Agriculture (%)	2.9	3.0	3.0	0.0
Industry (%)	15.8	8.9	11.0	–2.1
Services (%)	7.8	9.1	8.8	0.3
GDP value (billion kip)	62 458	102 320	81 229	21 091
Agriculture (%)	27.9	23.7	25.7	–2.0
Industry (%)	26.9	29.1	28.3	0.8
Services (%)	45.2	47.2	46.1	1.1
GDP per capita (USD)	1 217	1 970	1 548	422
Workforces (person)	138 486	155 181	145 165	10 016
Agriculture (%)	77.8	70.2	74.5	–4.3
Industry (%)	8.5	12.3	10.4	1.9
Services (%)	13.6	17.5	15.2	2.3

Table 12.3 Poverty headcount rates by regions in Lao PDR

Location	Poverty headcount rate					
	2003	2008	2013	Change (2003 and 2008)	Change (2008 and 2013)	Change (2003 and 2013)
Lao PDR	33.5	27.6	23.2	–5.9	–4.4	–10.3
Regions						
Vientiane Capital	16.7	15.2	5.9	–1.5	–9.3	–10.8
Northern Region	37.9	32.5	25.8	–5.4	–6.7	–12.1
Central Region	35.4	29.8	23.3	–5.6	–6.5	–12.1
Southern Region	32.6	22.8	29.2	–9.8	6.4	–3.4

The contribution to the GDP value from the industry, services, and agriculture sectors was 28.3 percent, 46.1 percent, and 25.7 percent, respectively (Table 12.2).

Agriculture continues to be an important sector for Lao PDR's economic growth and poverty eradication, providing employment for almost 75 percent of the workforce nationwide (Ministry of Planning and Investment, 2016).

12.1.1.4 Hunger and all forms of malnutrition

The prevalence of malnutrition in Lao PDR is complex and influenced by many interacting factors including geographic, economic, educational, and social dimensions. At the national level, malnutrition rates have steadily declined, except for wasting or acute malnutrition. The stunting rates (low height-for-age) of

children under five years (CU5) declined by 5 percent, from 38 percent in 2012 to 33 percent in 2017. Over the same period underweight rates (low weight-for-age) declined by 11 percent, but wasting rates (low weight-for-height) increased by 3.6 percent, from 5.4 percent in 2012 to 9.0 percent in 2017 (Lao Statistics Bureau, 2018).

12.1.1.5 Poverty

In conjunction with robust economic growth, poverty reduction in Lao PDR has gradually improved, from 33.5 percent in 2003 to 23.2 percent in 2013 (Lao Statistics Bureau, 2014). In addition, other socio-economic development indicators such as ownership of assets and access to services have significantly improved among the poor in both urban and rural areas.

Poverty in Lao PDR is unevenly distributed across the country's regions. Poverty reduction in the Northern and Central Regions has been impressive, declining by 12 percent between 2003 to 2013, relative to 3.6, and 1.1 times faster than the Southern Region and Vientiane Capital. The poverty reduction rate in the Southern Region, although impressive over the previous five-year period (2003–2008), was rather slow (only 3.4 percent over a ten-year period) due to a significant number of previous non-poor households falling back into poverty, causing poverty to increase by 6.4 percent, from almost 22.8 percent in 2008 to more than 29.2 percent in 2013 (Table 12.3).

12.1.2 About the mountainous regions of Lao PDR

12.1.2.1 Physical characteristics and demographics

Lao PDR is noted as having the highest percentage of steeplands in the Asia and Pacific region, being 89 percent (210 000 km²) of the country's land area, with 35 percent of the steep slopes between 4.5 degrees (8 percent) and 16.5 degrees (30 percent) and 45 percent of more than 16.5 degrees (FAO, 2000).

As a result, Lao PDR is the most mountainous country in the region. In Lao PDR, the definition of “mountain” is ambiguous; “upland” is used interchangeably with “mountain” making it difficult to collate some information on mountains. The mountain landscape exists in all provinces in varying proportions. The northern region is the main mountainous region of the country, with smaller upland mountainous areas bordering Viet Nam to the east.

Information on mountain populations is limited. Based on the AEZs (Table 12.1), approximately two-thirds of the Lao rural population live in the mountains (AEZ2, AEZ4, AEZ5, and AEZ6). The current Lao population is 6.5 million, with 67 percent living in rural areas; therefore, about 2.9 million people are estimated to live in mountain areas.

One of the important features of mountain areas in Lao PDR is that ethnic minorities (Mon-Khmer, Hmong-Mien, and Chinese-Tibetan) are more prevalent than Lao-Tai ethnic groups.

12.1.2.2 Economy

Lao PDR is largely an agrarian country with more than 70 percent of employed persons working in the agriculture sector followed by construction (8 percent), public administration and defense (6 percent), wholesale and retail trade (5 percent) and manufacturing

(4 percent). While there is little difference in the proportion of women (51.3 percent) and men (48.7 percent) engaged in crop and animal production, hunting, and related service activities, men are more involved in forestry and logging (66 percent) and fishing and aquaculture (72 percent) than women (Lao Statistics Bureau, 2015).

12.1.2.3 Hunger and malnutrition in mountain areas

Nationally, in 2017 about 33 percent, 21 percent, and 9 percent of children under 5 years of age was stunting, underweight, and wasting, respectively. The children in rural villages in the northern and southern regions are more likely to be malnourished than those living in urban areas and the central region. In addition, children in rural areas without road access are more likely to be stunted, underweight, and wasting than those in urban areas (Table 12.4).

The rates of malnutrition in children under 5 years vary between ethnolinguistic groups. The Lao-Tai group is better nourished than other ethnic groups, leading to lower rates of malnutrition in their children with 23 percent stunted and 17 percent underweight. The Hmong-Mien ethnic group has the highest rate of stunting (50 percent), followed by the Chinese-Tibetan group (49 percent), and the Mon-Khmer group (43 percent). The Mon-Khmer ethnic group has the highest rates of wasting (10 percent), followed by Lao-Tai (9 percent), Hmong-Mien (7 percent), and Chinese-Tibetan (5 percent).

Maternal education is also an important determinant of the health of children. Children with mothers with low or no formal education are 2.7 times more likely to be stunted, 2.7 times to be underweight, and 1.5 times to be wasted compared with those whose mothers have gone through more formal education.

Household incomes play a significant role in child malnutrition. The Lao Social Indicators Survey II (LSIS II) in 2017 identified an inverse relationship between the rates of malnutrition and income quintile. The highest rate of stunting was found in households with the poorest income quintile (48 percent), followed by second quintile (41 percent), the middle quintile (30 percent), fourth quintile (23 percent), and the richest quintile (14 percent) (Lao Statistics Bureau, 2018).

As such, malnourished families are more likely to live in rural areas in the northern and southern regions (main mountain areas) and are ethnic minorities with low educational levels and incomes.

Table 12.4 Nutritional status of children under 5 years in Lao PDR

Altitudes	Stunting (%)	Underweight (%)	Wasting (%)
Lao PDR	33.0	21.1	9.0
Region			
Northern Region	38.9	23.1	10.0
Central Region	28.8	17.8	7.6
Southern Region	34.0	25.7	10.7
Area of residence			
Urban	21.5	13.9	7.0
Rural	37.2	23.8	9.8
With roads	36.0	23.0	9.4
Without roads	43.3	27.4	11.5
Ethnic groups			
Lao-Tai	23.2	16.5	9.1
Mon-Khmer	43.3	29.5	10.2
Hmong-Mien	50.2	22.9	7.2
Chinese-Tibetan	48.6	23.7	5.8
Others	36.4	34.9	12.1
Mother's education			
None	44.8	28.7	10.5
Primary	34.6	22.5	9.2
Lower secondary	29.7	18.8	8.6
Upper secondary	22.0	12.4	7.7
Post-secondary	19.7	12.2	8.0
Higher	16.8	10.8	6.8
Wealth index quintile			
Poorest	48.0	30.7	11.9
Second	40.8	25.5	9.4
Middle	30.0	19.9	9.6
Fourth	22.8	14.8	6.5
Richest	13.9	8.4	6.0

Source: Lao Statistics Bureau, 2018

12.1.2.4 Poverty in mountainous areas

There is no poverty data specific to the mountains. However, the LSB 2014 estimated the poverty headcount rate in 2013 for the mountains (midland and upland) at 28.0 percent, which is higher than the national average of 23.2 percent (Table 12.4) (Lao Statistics Bureau, 2014). While poverty rates in the

mountains declined faster than the country's average (–12.1 percent vs. –10.3 percent), mountain poverty is still prevalent.

There is no land use data specific for mountain areas. Nationally, only 10 percent (2.8 million ha.) of the total land area is under cultivation, of which 58 percent is

Table 12.5 Poverty headcount rate by altitude in Lao PDR

Altitudes	Poverty headcount rate (%)		
	2003	2013	Change
Lao PDR	33.5	23.2	–10.3
Lowland	28.6	18.8	–9.8
Midland	36.7	22.0	–14.7
Upland	43.4	33.9	–9.5
Mountain areas	40.1	28.0	–12.1

arable land, which is much lower than neighbouring countries (Thailand, Viet Nam, Cambodia, and Myanmar). Forest land area equates to about 40.3 percent of the total land area (Ministry of Agriculture and Forestry, 2014).

In 2010/11, the total area of agricultural land was 1.62 million ha, of which 1.23 million, 0.20 million, 0.17 million, 0.03 million was land under temporary crops (rice, maize, sweet potatoes, cassava, sesame, groundnut, soybean, sugar cane, etc.), temporary fallow, and permanent crops (coffee, rubber, banana, cardamom, mango, tea, etc.), and meadows and pastures, respectively (Department of Planning, Ministry of Agriculture and Forestry, 2012).

12.1.3.2 Population: Mountain areas vs national

About two-thirds of the Lao rural population live in mountain areas and most are part of an ethnic minority.

12.1.3.3 GDP: Mountain agriculture vs country

There is no GDP data specific for mountain areas in Lao PDR. However, the contribution of mountain agriculture to the national GDP is substantial because the country is mostly mountainous with most of the 2.6 million rural people deriving their livelihood from agriculture.

12.1.3.4 Mountain agricultural activities and products

Rice is the staple food crop of Lao people, and upland rice production is the most important agricultural activity in mountain areas, along with some rainfed lowland and irrigated rice. Cash crop production is increasingly important due to the increasing demands from urban areas and surrounding countries. The principal cash crops are maize, job's tears (*Coix lacryma-jobi* L.), sweet corn, cassava, rubber, coffee, tea, cardamom, and fruit trees, such as banana, mango, citrus, etc. Rice shortages are common; forest products

are often gathered to make up the food deficit or to earn cash to buy rice. Livestock raising, including poultry, pigs, goats and cattle, is common. Forests, including fallow lands, are important grazing lands providing food and other Non-Timber Forest Products (NTFPs) for farming families.

12.1.3.5 Income: Mountain areas vs national, sources of livelihood (agriculture vs non-farm)

There is no income data to compare mountain and national incomes. Income from agriculture is universal for a country with concentrated rural areas, while non-farm income is generated in urban and peri-urban areas.

12.2 Mountain agriculture in Lao PDR: status, challenges and constraints

12.2.1 Status

12.2.1.1 Land utilization in mountain areas

There is no land utilization data specific for mountain areas. Land utilization by country is in section 1.3.1.

12.2.1.2 Main farming systems in mountain areas

The major farming systems in Lao PDR are 1) lowland rainfed, 2) irrigated, 3) upland, and 4) plateau. The predominant farming systems in mountain areas are upland and plateau farming systems. Mountain farming systems may incorporate small irrigation systems in valleys for rice production in the wet season.

Shifting cultivation is a traditional farming system commonly practiced in the mountain areas, particularly in the northern provinces. There are three systems of shifting cultivation:

- 1 **Pioneering exploitive system** is practiced in former opium poppy production areas but this system is not currently practiced in Lao PDR. In this system, the cleared land is continuously cropped until severely degraded, after which it is abandoned, and the cultivators move to a new forest area to continue the cropping cycle. The abandoned lands are invaded by imperata and other aggressive weeds and grasses and remain under these species which rarely recovers to become wooded forests due to severe degradation and wild fires.
- 2 **Traditional swidden rotational system** cycles for 15 to 20 years with 2 to 3 years of cropping. Upland rice is the main crop, commonly intercropped with other food crops, such as maize, tuber crops, and vegetables. This system is sustainable due to sufficient time in bush fallow to ameliorate soil fertility and suppress weeds and pests that build up during the cropping phase. This form of shifting cultivation is found in some remote areas where the population density is low, and the cycle is reduced to 5 to 10 years.
- 3 **Transitional shortening rotational system** is a common form of shifting cultivation in mountain areas. It is a transitional system to sedentary agriculture. Low productivity in these areas caused by short fallow periods and soil erosion has made the transition difficult.

The main farming systems in various elevators (altitudes) at the national level in the country are in Table 12.1. Except for AEZ1, shifting cultivation of upland rice and livestock raising are the dominant agricultural production.

12.2.1.3 Crops commonly grown in mountain areas

Upland rice remains the dominant crop, although production has decreased with the reduction in shifting cultivation areas. In addition to upland rice, farmers own small areas of terraced fields in valleys and along the Mekong tributaries for rainfed lowland and irrigated rice production. With increasing connections to domestic and regional markets, more cash crops are being produced including maize, job's tears, cassava, soybean, cotton, sugarcane, rubber, coffee, tea, cardamom, fruit trees and vegetables.

12.2.1.4 Animal production and grazing system in mountain areas

Animal production is an integral part of traditional farming systems in Lao PDR. In shifting cultivation, livestock farming is important for food, income, household saving, properties, transport, ritual use, and the utilization of agricultural waste products and fallow vegetation. In many shifting cultivation communities, animals provide the income needed to cover rice shortages and the purchase of market goods. Livestock raising has several advantages over most cash crop production, as it does not require road access since large animals can be herded along trails to market, thereby reducing transportation costs and, unlike perishable cash crops, animals can be sold when money is needed or when the price is satisfactory.

The most important animals raised in Lao PDR are chickens, pigs, goats, cattle, buffalo and horses. Fish farming has also become increasingly important.

12.2.2 Challenges and constraints for sustainable mountain agriculture

12.2.2.1 Socio-economic factors

Farmers in upland mountain areas are at high risk of losing their land tenure and land use rights caused by land allocation programme, unless they follow the rules and regulations agreed upon during the land and forest allocation process. Farmers are also at risk of inappropriate land concession and village resettlement when land is granted as concession for investors. Population growth has led to shorter fallow periods in traditional farming systems contributing to low productivity. Huge areas are being lost to plantations, mines and reservoirs, which greatly reduce farmer access to land. As land becomes scarce, instabilities are starting to emerge. Some communities complain that they have insufficient land to farm and graze their animals. With declining access to land and forests, poor farmer households need to outsource their labour to meet their food requirements. Outmigration is a consequence, with women and younger groups seeking employment in urban areas of the country or overseas, namely Thailand, Viet Nam, China, and others. According to one official estimate, 300 000 Lao people are working in Thailand (Bartlett, 2012). Other recent report revealed 250 000 registered and un-registered Lao workers in Thailand. These migrants frequently end up in low-status, low-wage production and service jobs where they are exposed to a higher risk of exploitation, violence, and abuse (The United Nations in the Lao PDR, 2015).

12.2.2.2 Natural resources and environment pressure on the agricultural production base

Lao PDR is inherently vulnerable to climate and other natural hazards due to its geographic and geophysical characteristics. It has high mountains and hills with steep slopes, varying elevations, narrow catchment areas, and enormous river and stream networks. Forests play an important role in protecting mountain slopes, small and large river banks and other natural features from the impacts of climatic variability, occasional extreme weather events and other hazardous events. However, forest cover in Lao PDR has decreased from 17 million hectares (or 71.8 percent of the total land area) in 1940, to 9.5 million ha. (or 40.3 percent of the total land area) in 2010 (Ministry of Natural Resources and Environment, 2016). The decrease in protective forest cover in Lao PDR makes the land more vulnerable to climate variability and change.

Major climate hazards that Lao PDR regularly face include flooding caused by heavy rainfall during the raining season, droughts caused by extended dry seasons, sudden flash-floods in the mountainous parts of the country, landslides and large-scale land-erosion on slopes, occasional windstorms and typhoons. These events can not only destroy productive land, agricultural assets and harvests, public infrastructure, and property, but alter the landscape, fauna and vegetation.

Agricultural production based on large-scale monoculture farming for export earnings has reduced the diversity in crop varieties and indigenous production techniques, leading to greater vulnerability to climate risk.

Most rural and remote village dwellers in Lao PDR have experienced unusual highs and lows in the daily weather pattern, shorter rain seasons, and reduced rainfall. These new climatic variations challenge the traditional approaches to farming. In addition, changes in the quantity and timing of rainfall and floods have an immediate effect on crop production. Some known rice varieties no longer grow under the new climatic conditions. Indeed, changes in temperature and humidity bring new species of pests and diseases to animals and plants that are unknown to farmers.

The people of Lao PDR are particularly vulnerable to climate change because 80 percent of livelihoods are associated with some form of agricultural activity; poor, rural farmers are the most vulnerable with a limited asset base and lack of access to support provided by the state.

12.2.2.3 Technical constraints

Mountain agriculture is in a gradual transition from subsistence to permanent, market-oriented production systems, as a result of increased population pressure and land use restrictions imposed by governments for environmental reasons that have led to shorter fallow periods causing a decline in essential natural resources that support the productivity and sustainability of the traditional system. This transition, combined with highly diverse mountain ecosystems and extreme weather and climate variability caused by climate change, will require new agricultural practices and technologies to boost farmer confidence in modified farming systems. Promoting sustainable mountain agriculture production is constrained by a lack of financial and human resources in research on “new agriculture” and extension services that can facilitate the transition with technical assistance that provides culturally sensitive and appropriate advice to farmers.

12.2.2.4 Market constraints

Commercial agriculture is being promoted as an alternative to shifting cultivation. Most of the areas currently planted to commercial crops were used for upland rice only a decade ago. Marketing of agricultural and forest products has created new livelihood opportunities for subsistence farmers. However, not all households in the mountains can take advantage of these opportunities, with some farmers making a good income, while others are finding it hard to survive.

There is a wide range of agricultural and forest products that could be explored for niche products and marketed domestically and regionally. However, there many market-related constraints faced by farmers as producers: low commodity price, lack of knowledge and limited information on agricultural diversification, limited markets for diversified agricultural produce, inadequate working capital and access to financial services, undeveloped farms to market road network, transportation shortage and high transportation costs, and lack of access to market information.

12.2.2.5 Physical and infrastructure

In 2011, the road network in Lao PDR was limited, with only 16 percent of roads paved. About one in three villages in the country had gravel or dirt roads, facing greater risk of losing year-round road access. Roughly 9 percent of villages, mainly in the northern region, had no roads.

Mountain remote villages with no road access or no year-round road access often have limited access to markets, which significantly limits the alternative land use options available to farmers. In addition, limited access to a road network restricts access to essential public services in education, health care, agricultural extension, and employment. This means that further road network development in mountain areas is a prerequisite for most of the development initiatives, particularly reducing poverty, food insecurity and malnutrition in vulnerable households and communities.

Besides the benefits, road expansion encourages settlements and land use change, which often leads to agricultural expansion on unsuitable land, land disputes, and land grabbing. Road construction is also frequently followed by illegal logging and forest encroachment by farmers and investors.

Road construction in mountain areas requires high construction and maintenance costs. As a result, alternative road construction in mountains needs to balance between the social, economic, and environmental benefits.

12.2.2.6 Policy and institution constrains

The government developmental policies aimed at improving social and economic livelihoods in mountain areas are largely based on efforts to stabilize shifting cultivation for which Ministry of Agriculture and Forestry (MAF) is taking the lead, while other governmental ministries provide the necessary ancillary support (roads, social services, etc.) to ensure an enabling environment to foster agriculture and forestry development in the country, particularly in rural areas. To ensure smooth implementation of national policy and strategy, the National Agriculture and Forestry Research Institutes (NAFRI) and the National Agriculture and Forestry Services (NAFES) under MAF were established with an “area-based approach” to rural development, known as an “area-based livelihood systems approach” or “Focal Site approach”. The newly established institutions and decentralized approach provide a solid platform for greater participation and more effective coordination within MAF’s departments and between concerned ministries in delivering innovation support to the provinces, districts, and villages within each focal site.

However, there are many constraints to modifying existing approaches to mountain agricultural development related to land use, mountain slopes

and forest protection. These include gaps in policy framework, weak intersectoral as well as national/local coordination, limited institutional and individual capacity for risk assessment, planning and management, limited technical knowledge and know-how (e.g. information management and analysis, technical approaches to mountain agricultural extension, and community-based approaches for agricultural and rural development) and major financial constraints.

12.3 Opportunities and entry points for mountain agriculture development to address Zero Hunger and poverty reduction

12.3.1 Agriculture diversification and sustainable intensification

Shifting cultivation is a predominant form of production system used in the uplands and mountain environments. This subsistence system is highly diversified combining crop and livestock production and forestry. Where possible, valley bottoms with floodplains are converted to lowland rice production. Given the highly diversified agro-ecosystems and abundance of biodiversity, a variety of crops and animals with potential for food, income, and nutrition can be explored and promoted. Diversifying crops from rice production to mixed cropping with Future Smart Foods would not only help to build resilience to climate risks but improve food security and income.

12.3.2 Agro-processing activities for agriculture products

Agro-processing activities in upland mountain areas are limited. Important cash crops such as maize, rice, job’s tears and NTFPs are exported with little value-addition. Geographically, Lao PDR is predominantly mountainous with hills and steep terrain covering two-thirds of its land area with scattered settlements and agricultural land. As such, agro-processing activities are small to medium-sized enterprises scattered along the main production areas in villages with better infrastructure. Local processing of raw agricultural and forest produce will help to increase farmer income, encourage agriculture diversification, and provide off-farm employment.



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12.3.3 Value-addition measures and activities for agriculture products

Most Lao farmers depend on subsistence agriculture. Production is mainly for home consumption. They commonly practice natural agriculture and rarely use external inputs such as improved seeds and chemicals to increase productivity. This provides a solid foundation for the expansion of organic farming. Four different systems are commonly used for organic production in Lao PDR: 1) fallow rotation (shifting cultivation) system, largely for upland rice production for home consumption, with job's tear, sesame, and maize as the most important exported crops. Although not formally certified, they are often referred to as "organically grown"; 2) wild products collected in forest and fallow land for home consumption, local markets, and export; 3) fruits, mostly produced without external inputs; and 4) market-driven organic production. System 1–3 are largely "organic by default". Products from these systems are usually not certified as "organic" and farmers generally do not receive premium market prices. System 4 crops, including maize, rice, cardamom, garlic, castor bean, potatoes, job's tears, sesame, vegetables, banana, pineapple, and oranges, are produced and marketed as "pesticide-free" or using "natural practices/organic farming" (EDC, 2003).

Lao PDR has a range of conditions which favour organic production for domestic consumption and exports including 1) low external input systems that allow for easy conversion to an organic system, 2) a reputation for low levels of pesticide residues, and 3) hill environments that offer opportunities for a wide variety of fruits and vegetables.

There is a strong commitment from the government of Lao PDR and especially the MAF to support organic agriculture. With the support of international donors and NGOs, standards and legislation have been developed and introduced to the local certification system. Currently, 45 farmer groups cultivating 10 000 ha in Lao PDR are registered as organic agriculture, representing more than 3 000 households.* So far only a few crops including lowland rice, coffee, and tea have been certified organic. Despite the enormous opportunities, organic farming needs substantial investment and appropriate strategies for certification and branding to be in place.

12.3.4 Social protection measures targeting on mountain people

Graduation from the Least Developed Country (LDC) status by 2020 requires an equity economic growth and achieving the growth will never be realized without paying attention to social protection measures. A government social protection programme should target communities and people who are vulnerable to food insecurity. These people are often the poor and ethnic minorities, smallholder farmers with low education, landless and wage labourers, disaster victims, disabilities, children and elderly people whose social, economic status and rights need to be strengthened so that they can participate in wide economic activities when opportunities become available.

Diversification is crucial and a key measure in building resilience to climate risks. Well-targeted subsidiary measures (finance, in-kind, logistics, scholarship, market access, etc.) are needed to make food production more rewarding for farmers and should be used as an incentive for better land management practices and to support opportunities for non-farm income.

12.3.5 Sustainable food production

Many research studies and reports have identified negative effects associated with the shifting cultivation eradication policy and strategy. Upland mountain farmers have traditionally practiced a form of agroforestry based on shifting cultivation, with a mixture of upland crop production and livestock raising that makes sustainable use of natural resources. There is extensive literature on shifting cultivation in Lao PDR, but a lack of agreement among high-level decision makers on how the productivity and sustainability of the system that could be applied for sustainable agricultural diversification and intensification in mountain areas.

Some forms of traditional farming system are highly resilient to a range of shocks and vulnerabilities influenced by external factors. Eradication of shifting cultivation involves the eradication of these traditional systems, which are the only food security strategy used by thousands of upland mountainous farmers. To ensure sustainable food production in mountainous area, negative impacts on livelihoods and natural resources will have to be minimized by restricting certain types of investment (e.g. resettlement, land concessions) or reconsidering certain issues of laws and policies (e.g. Forest Law, shifting cultivation stabilization, agricultural commercialization, environments, etc.).

* For more information visit FAO in Laos: www.fao.org/laos/news/detail-events/en/c/896040

Ongoing investments and policies should focus on mitigation measures for those who are affected by large-scale projects in hydropower, mining, relocation of villages, and natural disasters.

12.4 Country experience

12.4.1 Good agricultural practices on sustainable and integrated farming in mountain areas

Linking farmers with nutritious food, food safety, value-addition, and quality of life for food security requires “Good Agricultural Practices” (GAPs). In Lao PDR, GAPs are widely promoted to produce safe food, while conserving the environment and increasing farmer income. The Department of Agriculture under MAF provides technical training and certification for GAPs and organic products. GAP codes, standards and regulations have been jointly developed in recent years by the food industry and producers’ organizations, government agencies and NGOs, who aim to codify agricultural practices at the farm level for a range of commodities. The objective of these GAP codes, standards, and regulations include ensuring safety and quality of produce in the food chain, capturing new market advantages by modifying supply chain governance, improving natural resource use, worker health and working conditions, and/or creating new market opportunities for farmers and exporters in developing countries.

12.4.2 Policy measures and initiatives for sustainable and inclusive mountain development

Extensive development targeting uplands/mountains has taken place since 2000 when the Lao PDR government recognized that economic growth of two zones – the flat Mekong corridor and the sloping upland – started to diverge and required separate development strategies. Since then the government’s policies and strategies directed to upland development have evolved over time, particularly with regard to the policy on stabilizing shifting cultivation. The government viewed shifting cultivation as unsustainable, and intended to stabilize it to protect the environment and eradicate poverty by (1) sedentarizing agriculture on sloping land through farming systems diversification and agro-forestry development, (2) developing market access to communities through feeder road development and market information delivery, (3) promoting land use zoning based on land capability and slope, (4) promoting rural savings and credit

provision for alternative livelihoods, and (5) implementing land allocation and land use occupancy entitlements (Ministry of Agriculture and Forestry, 1999).

After nearly two decades of implementation, mountain development has substantially increased, including the expansion of roads and mobile phone networks and market monopoly, granting of a land concession, logging, hydropower, village resettlement and efforts to eradicate shifting agriculture. Separating the impact of one individual development from another may not be possible, but the combined result has been cited by one researcher as “the collapse of traditional livelihood systems” (NAFRI, NAFES, NOUL, 2006). Land concessions, resettlement and land and forest allocation are key development interventions causing negative impacts on livelihoods and mountain ecosystems. Nevertheless, development is creating new livelihood opportunities for many rural people.

12.4.3 Case study

Benzoin production in Huaphan province, Northern Lao PDR

The intervention is reducing the vulnerability of the poor by providing them with cash income from NTFPs (benzoin and lac) obtained from indigenous trees (*Styrax tonkinensis*). This supplementary cash income improves food security and self-sufficiency by providing financial resources to purchase food during periods of shortage. By offering producers higher prices from the investor for benzoin that meets the minimum quality standards, investors can empower poor communities. The local farmers are being given the opportunities to receive an increase in their share of value-added based on the company’s system of purchasing four grades of benzoin.

The approach used by the investors could be replicated elsewhere in Lao PDR. The blend of indigenous technical knowledge and modern tree planting techniques to produce an export product with a ready market is attractive to farmers. They also benefit from technical assistance related to value-added processing at the family and community levels. The relationship between the company and the producers is based on trust using the traditional verbal contract approach rather than a written contract, which is legalistic and semi-literate villagers would likely hesitate to sign. In addition, the company wisely uses respected people in the community to represent the company, as a local manager and as extension and purchasing agents (Bartlett, 2012).

12.5 Strategic consideration and suggestion

12.5.1 Policies

The policy framework and strategies for food security and poverty eradication are set out in the following key documents

The 8th National Socio-Economic Development Plan 2016–2020 (NSED) sets out the Lao PDR government's social and economic development strategy and policy aimed at graduating from LDC status in 2020. The 8th NSED contains seven strategies, which are integrated with the targets for SDG 2. The food and nutrition security, which is closely linked to SDG2, is included in the second strategy "Graduation from LDC status by 2020 and meeting SDGs" of the 8th NSED. The plan aims for sufficient food with comprehensive nutrition, increased agricultural productivity, rehabilitation of forests (with the target of 70 percent forest cover), support for agriculture based on the suitability of land and climate (agro-ecology), and the promotion of GAPs (Ministry of Planning and Investment, 2016).

The National Nutrition Strategy 2025 and Plan of Action 2016–2020 (NNSPA) is the national strategic policy document for multisector efforts to improve nutrition in Lao PDR. The NNSPA aims to contribute to the adoption of the 8th NSED and seeks to achieve SDG 2 "End hunger, achieve food security and improved nutrition and promote sustainable agriculture" and contributes directly to several other SDGs.

The strategic directions and objectives of the NNSPA are to:

- ◆ Tackle the immediate causes of hunger (at the individual level) and focus on achieving sufficient food consumption and safety, emphasizing the first 1 000 days of life, and reduce the prevalence of disease caused by contaminated food and indirectly transmitted infectious diseases, which impair the body's ability to absorb food consumed
- ◆ Tackle the underlying causes of malnutrition (at household and community levels), which requires improvements in the safety and diversity of food consumed so that people have access to food at all times in all locations, and focus on improving mother-and-child health practices, clean water systems and sanitation, and providing healthy environments and access to health services.

The strategy also emphasizes multi-sector efforts in 22 priority interventions; of these, besides health, education, and multisectoral, four interventions fall under the agricultural sector: 1) increase the production of nutritionally rich plant-based foods for household consumption, 2) increase the production of animal-based protein (meat, poultry, fish, and other aquatic life) for household consumption, 3) support the establishment of post-harvest facilities and apply technology to food processing, preservation and storage to ensure year-round availability of safe and nutritious food, 4) promote agriculture-based and NTFP-based income generation activities to increase household incomes with an emphasis on women (Government of Lao PDR, 2015).

The Agriculture Development Strategy (ADS) 2025 and Vision to 2030 is the core strategy of the MAF.

This strategy aims to ensure food security, produce competitive agricultural commodities, develop clean, safe and sustainable agriculture, and gradually shift to the modernization of a resilient and productive agriculture economy, with rural development contributing to the national economic base (Ministry of Agriculture and Forestry, 2015).

Although the strategy is focused on expanding farming systems for commodity production and improving regional and global market connections, its overall strategic orientation is on food and nutrition security. The strategy is flexible and responsive to innovative approaches and technologies that would help to achieve SDG 2. It provides a platform for the integration of quality food production within AEZs, social protection for producers vulnerable to natural disaster, gender equality in agriculture, technical training and technology application, climate-resilient agriculture, and access to agricultural land and credit. The strategy remains open for modifications and will be reviewed and revised on a regular basis to be consistent with government policies and socio-economic development needs.

12.5.2 Measures and interventions

The 8th NSED reiterates the government's aim to graduate the Lao PDR from the ranks of LDCs by 2020 and improve living standards of Lao population for greater social equity and stability. These goals will not be realized without addressing food insecurity and poverty while preserving the country's rich natural and cultural resource endowment for the benefit of its present and future generations of mountain people, and the nation. Actions are needed to avoid, or at least to some extent reduce, a range of risks and vulnerabilities the farm

households or almost 80 percent of Lao people face. Following, but not limited to, are the measures and interventions recommended:

- ◆ Enhance implementation of the 2025 NNSPA and Action Plan 2016–2020, 2025 ADS and Vision 2030, and National Strategy on Climate Change to allocate sufficient resources to support agro-ecology-based, climate-adaptive, nutrition-sensitive local food production and supply with a focus on mountain areas.
- ◆ Enforce and implement existing policies and strategies on climate change adaptation, watershed management, agricultural extension, forest management and land management, and promote agricultural diversification. The productive, fertile lands must be reserved for agriculture that increases food and nutrition security.
- ◆ Strengthen research–extension–farmer linkages focusing on sustainable local nutritious and food production. Agricultural extension plays a critical role in disseminating knowledge, technologies and agricultural information, and linking farmers with other value-chain actors. Sufficient linkages among researchers, extensionists and farmers could facilitate demand-driven research and technologies that promote agricultural productivity as farmers have sufficient knowledge to better deal with risks and vulnerabilities.
- ◆ Protect the country's biodiversity in protected areas including the National Biodiversity Protected Areas, national-, provincial-, district-, and village-protected forest areas through enforcement of the 2013 Environmental Protection Law, Forest Law for *in situ* conservation. Expand research on local genetic resources aimed at climate adaptation and food and nutrition security. Preserve threatened local varieties of economic and health potential to assure future availability and analysis.
- ◆ Promote safe dietary diversity through the consumption of locally available nutrient-rich foods. Efforts should involve raising awareness of the country's wide diversity value of fruits, vegetables, meats, fish, aquatic animals and insects, introducing GAPs suited to local agro-ecological conditions and markets, and promoting investments in natural resource management and environmental protection such as propagation and sustainable use of NTFPs to ensure a sufficient supply of natural-nutritious food.
- ◆ Reduce food safety risks for both production and consumption by strengthening guidelines for the safety of pest management, enforcing sanitary and phytosanitary inspection protocols during production and marketing of fresh products, and raising awareness of the nutritional content of packaged and processed foods, especially sugar, fat and sodium.
- ◆ Develop and implement a nationwide, large-scale reforestation and carbon-sink research and development programmes to increase forest cover, ensure proper watershed management, conserve and sustainably use biodiversity, diversify smallholder farming systems, and create local employment through the reforestation schemes and small-scale processing. Experiences from this nationwide programme are then used to develop a new concept and workable approach to sustainable development in the mountains.
- ◆ Conceptualize social protection as a strategic mechanism for vulnerable, disabled and disaster-affected populations. This may include conditional and unconditional cash and food transfers to promote agricultural diversification, with a focus on the poor and poor-prone families.

12.5.3 Governance

The government of Lao PDR has committed to addressing food and nutrition security, as shown by the inclusion of food and nutrition security in the 8th NSEDP, the formation of National Nutrition Committee (NNC) and Sector Working Groups (SWG), and the announcement of new funding to reinforce efforts toward achieving the SDG 2 target.

Lao PDR has an extensive range of strategies, action plans, sectoral policies and strategies. However, implementation of these policies and plans lags behind the outcomes and objectives specified in the policy documents (Ministry of Planning and Investment, 2016). The existing Lao governance system faces difficulties in addressing complex, multisector and interdisciplinary issues, as demonstrated by inefficient management of financial and human resources, disconnection between policy and strategy planning at central levels and implementation at subnational, provincial and district levels. There is also the problem of poor coordination of existing coordination bodies (NNC, SWGs, provincial and district counterparts). Owing to unclear authorized mandates, the provincial and/or district counterparts

were uncertain about whether they had the authority to act. In addition, the local authorities failed to meet the national policy commitments because of a lack of financial support (sometimes due to a lack of information on how to access funds from the national level) and capable personnel.

To overcome these challenges, a project specific to mountain areas needs to be developed and implemented. A typical project should have a clear organizational structure with direct lines of communication, some degree of autonomy in decision making, sufficient funding and qualified personnel with a multisector pool of expertise.

12.6 Conclusion

Socio-economic development for agricultural diversification and intensification with increased production and productivity, improved value-addition, and expanded marketing and sales has occurred in the flatlands along the Mekong corridor. The upland mountains did not benefit as expected despite the abundant agricultural production base and richness of natural resource endowments which are highly potential for agricultural diversification and intensification. In rural mountainous areas, acute poverty, chronic malnutrition and natural resource degradation are still prevalent. Rural development addressing the current poverty and malnutrition rate to end poverty and zero hunger would require more targeted, multi-sectoral and interdisciplinary efforts in terms of research and development, and monitoring and evaluation. The supports from development partners will be crucial as Lao PDR is committed to graduating from the Least Developed Country status by 2020.

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13 Myanmar

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13.1 Overview

13.1.1 About the country

13.1.1.1 Physical characteristics

The Republic of the Union of Myanmar is in the western portion of mainland Southeast Asia and is a member of the Association of South-East Asian Nations (ASEAN). The country is bordered by China to the north and northeast, Lao PDR to the east, Thailand to the east and southeast, Bangladesh to the west, India to the northwest and the Andaman Sea and Bay of Bengal to the south and southwest.

The total land area is 676 577 km²; the elevation ranges from sea level in the delta and coastal regions in the south to the only snowcapped peak in ASEAN (Mount Khakaborazi; 19 296 ft) in the north. The country is divided into seven regions, seven states and one union capital territory (Naypitaw).

Myanmar has four major agro-ecological zones:

- ◆ Delta region (Ayarwaddy, Yangon, Bago, Mon)
- ◆ Coastal region (Rakhine, Taninthari)
- ◆ Central Dry Zone (Mandalay, Magway, Sagaing)
- ◆ Hilly and Mountain region (Kachin, Kayah, Chin, Shan, Kayin).

Although Myanmar is in the monsoon region of Asia and is generally a tropical country, the climate varies depending on geographical position, elevation and distance from the sea. Myanmar has a winter season (November to February), summer season (March to May) and rainy season (June to October).

13.1.1.2 Demographics

According to the National Census in 2014, Myanmar has a population of 51.7 million and population density of 76 people/km². The population density varies between states and divisions; the highest being 400–700 people/km² in divisions comprising metropolitan and major cities, with medium population density in the delta region and lowest in the hilly regions

of Kachin, Kayah, Chin and Shan states. About 70 percent of the population is settled in rural areas, which mainly rely on agriculture for their livelihood. About 20 percent are settled in mountain areas. Myanmar has 135 officially recognized ethnic groups.

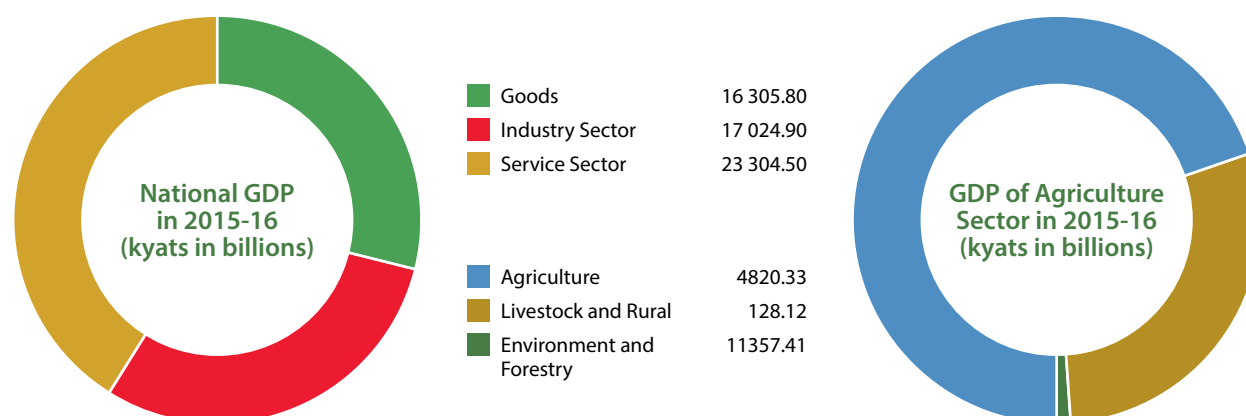
13.1.1.3 Economy

The agriculture sector is a high priority for the government of Myanmar. Agriculture contributes 30 percent to the national Gross Domestic Product (GDP) and about 68 percent of the rural population relies on crop husbandry and livestock for their livelihood and income.

From 2011, Myanmar was engaged in a process of political and economic liberalization to transform the country's economy and society; this will see the nation emerge as an important economic entity in ASEAN and wider regional and global economies.

After decades of isolation and the lifting of sanctions, Myanmar is actively re-engaging with the global economy. Myanmar's rich natural resource base, abundant labour and strategic location are an opportunity for foreign investment. Myanmar's GDP increased by more than 8 percent per year from 2010–11 to 2016–17. At the same time, the agricultural GDP increased by 3.2 percent per year. In addition to annual crops (including oilseeds and vegetables), Myanmar produces industrial crops (e.g. rubber, sugarcane, cotton, oil palm, coffee, tea), fisheries (e.g. shrimp) and livestock (e.g. cattle and poultry). It has abundant natural resources including fertile and diverse agro-ecological land areas (the largest land area in continental Southeast Asia), water, forests, and more than 2 000 km of coastline. The irrigated area covers about 16.2 percent of the total sown area.

Initial investments by public, private, partnership including Foreign Direct Investment have been primarily in tourism, mining, gems and infrastructure, but there is a growing interest in developing Myanmar's agricultural and agroprocessing sectors. Agriculture, livestock and fisheries account for about 56 percent of employment

Figure 13.1 National GDP of Myanmar and proportion of GDP from the agricultural sector

Source: Myanmar Agriculture at a Glance 2016, Ministry of Agriculture, Livestock and Irrigation

Table 13.1 Poverty in Myanmar

	Poverty headcount (%)	Poverty gap (%)	Poverty squared gap (%)
National	32.1	8.4	3.3
Urban	14.5	2.8	0.9
Rural	38.8	10.6	4.2
Hill and Mountain	40.0	12.1	5.1
Dry Zones	32.1	7.3	2.4
Delta	26.2	6.4	2.4
Coastal	43.9	14.4	6.6

Source: Myanmar Poverty and Living Condition Survey (MPLCS) 2017 conducted by the World Bank and Ministry of Planning and Finance, Government of Myanmar

and 25 percent of exports, earning more than USD 2.9 billion in 2016–17 through exports of beans and pulses, oilseeds, rice, shrimp, livestock, and rubber. Historically, rice has been the major agricultural export commodity; more recently, beans and pulses have, on average, generated higher export earnings.

13.1.1.4 Hunger and all forms of malnutrition

To meet Goal 2 of the United Nation's Sustainable Development Goals (SDGs), Myanmar is aiming to achieve zero hunger, improve food security and promote sustainable agriculture by 2030.

In recent decades, Myanmar has made significant improvements in the fight against hunger with the percentage of the population receiving less than the minimum level of calories declining by more than 77 percent since 1990. This means that Myanmar achieved the United Nations Millennium Development Goals (MDGs) of halving hunger by 2015.

13.1.1.5 Key indicators for poverty

According to the Myanmar Poverty and Living Condition Survey (MPLCS) 2017, conducted by the World Bank and Government of Myanmar:

- ◆ One-quarter of poor children do not complete primary school
- ◆ One in ten households fail to meet their food needs
- ◆ Half of the households are affected by weather, health or income incidents
- ◆ During the dry season, 4 in 10 households do not have access to an improved water source

Reducing poverty and increasing the wellbeing of poor and vulnerable populations is a priority for the government of Myanmar and its development partners.

Poverty in Myanmar's farms and villages (rural areas) is substantially higher than that in its towns and cities (urban areas): 38.8 percent of the rural population are

Table 13.2 Food poverty in Myanmar

	Poverty headcount (%)	Poverty gap (%)	Poverty squared gap (%)
National	9.8	2.1	0.8
Urban	2.7	0.4	0.1
Rural	12.5	2.8	1.0
Hill and Mountain	15.9	3.5	1.2
Dry Zones	7.4	1.2	0.3
Delta	6.9	1.5	0.5
Coastal	19.1	5.2	2.1

Source: Myanmar Poverty and Living Condition Survey (MPLCS) 2017 conducted by the World Bank and Ministry of Planning and Finance, Government of Myanmar

Table 13.3 Calorie intake (adult equivalent per day) and food share of total household consumption in Myanmar

	Calorie intake	Share of food (%)
National	2 463	59
Urban	2 097	46
Rural	2 604	64
Hill and Mountain	2 255	59
Dry Zones	2 509	56
Delta	2 507	60
Coastal	2 512	63

Source: Myanmar Poverty and Living Condition Survey (MPLCS) 2017 conducted by the World Bank and Ministry of Planning and Finance, Government of Myanmar

estimated to be poor compared to 14.5 percent of those in its towns and cities. This amounts to 15.8 million poor in total, of which 13.8 million live in rural areas and 2.0 million in urban areas. MPLCS Survey, 2017 shown that a decline in poverty rate from 48.2 percent in 2004/05 to 42.4 percent in 2009/10 and 32.1 percent in 2015.

13.1.1.6 Development and health indicators

Myanmar's human development index value was 0.556 in 2015 – placing the country in the medium human development category at 145 of 188 countries and territories – below the average of 0.631 for this category and 0.720 for countries in East Asia and the Pacific. The Demographic and Health Survey 2015–2016 indicated that 76.4 percent of 6–11-month-olds and 74.8 percent of 12–23-month-olds suffer from anaemia, along with 46.6 percent of women of reproductive age. Of children under 5 years of age, 29.2 percent are stunted, 7 percent are wasted, and 18.9 percent are underweight. Only 16.0 percent of children aged 6–23 months are fed the minimum acceptable diet (MAD), which looks at both frequency of feeding to children and the number of food groups children eat.

13.1.2 About mountains in Myanmar

13.1.2.1 Physical characteristics and demographics

The mountain regions of Myanmar are found in five states namely Kachin, Kayah, Kayin, Chin and Shan. This region has a population of about 6.5 million, with the majority in Shan State. There are 118 ethnic groups in the mountain region. Most farmers cultivate a wide range of rainfed tree crops and horticulture products along with rice, maize and pulses.

The major economic activity in the mountain region is agriculture. Other popular activities are jade mining in Kachin, tourism in Kayah and Kayin, border trade in Kachin, Shan and Kayin, livestock in Chin, Kayin and Shan. Social issues relating to migrant workers who leave their home state to work in other country are evident in all states, especially border regions of Kachin, Shan, Kayah and Kayin.

Table 13.4 Elevation range in the mountain region states of Myanmar

State	Lowest elevation (ft)	Highest elevation (ft)
1 Kachin	284	19 296*
2 Kayah	537	3 260
3 Kayin	56	3 717
4 Chin	178	6 120
5 Shan	600	5 332

* Mount Khakaborazi is the highest peak in Myanmar

Table 13.5 Major economic activities and sources of livelihood by mountain region state in Myanmar

State	Lowest elevation (ft)	Highest elevation (ft)
1 Kachin	Agriculture, mining, trade	Agriculture, migrated workers
2 Kayah	Agriculture, livestock	Agriculture
3 Kayin	Agriculture, livestock, industry, trade	Agriculture
4 Chin	Agriculture, livestock	Agriculture, livestock, migrated workers
5 Shan	Agriculture, livestock, mining, industry, trade, tourism	Agriculture

Table 13.6 Poverty rate in mountain regions compared with national poverty rate in Myanmar

	Poverty headcount (%)	Poverty gap (%)	Poverty squared gap (%)
National	32.1	8.4	3.3
Coastal	40.0	12.1	5.1

Source: Myanmar Poverty and Living Condition Survey (MPLCS) 2017 conducted by the World Bank and Ministry of Planning and Finance, Government of Myanmar

13.1.2.3 Poverty

According to Myanmar Poverty and Living Condition Survey (MPLCS) 2017 conducted by the World Bank, poverty rate in mountain region was higher than national poverty rate.

13.1.3 About contribution and percentage of mountain agriculture in Myanmar

Table 13.7 Land classification and distribution in mountain areas vs. country in Myanmar

Particular	Mountain region ('000s)	Country ('000s)	Country share (%)
1 Net sown area	2 158	12 008	18
2 Fallow land	252	450	56
3 Cultivable waste land	1 921	5 247	37
4 Reserved forest	7 824	18 555	42
5 Other forest land	11 203	14 742	76
6 Other land	8 954	16 659	54
Total land area (ha)	32 312	67 659	48
Total land area (km ²)	323	676	48

Source: Myanmar Agriculture at a Glance 2016, Ministry of Agriculture, Livestock and Irrigation

Table 13.8 Population: Mountain areas vs. country in Myanmar (2014)

State	Mountain region ('000s)			Country share (%)		
	Male	Female	Total	Male	Female	Total
1 Kachin	886	818	1 704	4.0	3.0	3.0
2 Kayah	145	144	289	0.6	0.5	0.6
3 Kayin	781	807	1 588	3.0	3.0	3.0
4 Chin	231	250	481	1.0	1.0	1.0
5 Shan	2 931	2 929	5 860	12.0	11.0	11.0
Mountain region total	4 974	4 948	9 922	20.0	18.0	19.0
Country total	24 936	26 765	51 702			

Source: Department of Planning, Ministry of Planning and Finance

Table 13.9 GDP: Mountain agriculture vs. country in Myanmar

State	Total GDP (billion kyats)	Agriculture sector GDP (billion kyats)	Contribution of agri-sector to total GDP (%)	Contribution of agri-sector to national GDP (%)	Contribution of agri-sector to national agri-sector GDP (%)
1 Kachin	1 102.88	215.06	19.5	0.38	2.05
2 Kayah	204.85	53.26	26.0	0.09	0.51
3 Kayin	1 063.04	319.97	30.1	0.57	3.04
4 Chin	208.74	32.98	15.8	0.06	0.31
5 Shan	3 566.54	1 030.73	28.9	1.83	10.31
Mountain region total	6 146.04	1 652.01	26.9	2.93	15.71
National total	56 476.23	10 515.83	18.6		

Table 13.10 Main mountain agricultural activities and products in Myanmar

State	Main agricultural activities	Products
Kachin	Crop farming, livestock	Rice, corn, soybean, vegetables, poultry, milk, forest products
Kayah	Crop farming, livestock	Rice, corn, sesame, vegetables, forest products
Kayin	Crop farming, aquaculture	Rice, rubber, fish
Chin	Crop farming, livestock	Fruit, elephant foot yam, pine wood, pine oil, wild cow meat, goat
Shan	Field crops, horticulture, livestock	Corn, mango, tomato, garlic, soybean, potato, tea, coffee, orange, avocado, sunflower, vegetables, chicken, eggs, goat, cattle, teak, bamboo, charcoal

Table 13.11 Income of Myanmar

State	2015–16 (in Kyat)
1 Kachin	831 092
2 Kayah	861 369
3 Kayin	834 256
4 Chin	576 357
5 Shan	727 811
National	1 079 262

13.2 Mountain agriculture in Myanmar

13.2.1 Status

13.2.1.1 Land utilization in mountain areas in Myanmar (Acre)

State	Agriculture	Livestock	Forestry	Total
1 Kachin	777 387	583	7 005 490	7 783 460
2 Kayah	166 832	0	1 562 100	1 728 932
3 Kayin	1 196 544	38 881	3 039 446	4 274 871
4 Chin	172 937	8 040	2 200 323	2 381 300
5 Shan	3 017 231	0	8 538 254	11 555 485
Total	5 330 931	47 504	22 345 613	27 724 048

13.2.1.2 Main farming systems in mountain areas in Myanmar

State	Main farming systems
1 Kachin	Arable farming, extensive farming system of cereal crops, shifting cultivation
2 Kayah	Arable farming, extensive farming system of cereal crops, shifting cultivation
3 Kayin	Arable farming, intensive farming system of paddy, maize
4 Chin	Arable farming, shifting cultivation, pastoral, mixed cropping, subsistence farming
5 Shan	Arable farming, intensive farming system of paddy, maize, vegetables, horticulture, pastoral

13.2.1.3 Crops commonly grown in mountain areas in Myanmar

State	Crops
1 Kachin	Rainfed paddy, upland paddy, maize, pulses, rubber, fruit trees
2 Kayah	Rainfed paddy, maize, sesame, upland paddy, peanut, pulses
3 Kayin	Rainfed paddy, maize, rubber plantation, upland paddy
4 Chin	Upland crops, e.g. paddy, millet, pulses
5 Shan	Rainfed paddy, maize, pulses, coffee, tea, fruit trees, upland paddy, vegetables, rubber, sugarcane

13.2.1.4 Animal production and grazing system in mountain areas in Myanmar

State	Animal production and grazing system
1 Kachin	Range system without pasture
2 Kayah	Range system without pasture
3 Kayin	Range system without pasture
4 Chin	Range system without pasture
5 Shan	Range system without pasture

13.2.2 Challenges and constraints for sustainable mountain agriculture

13.2.2.1 Socio-economic factors

State	Challenges and Constraints
1 Kachin	Aging index 13.2, elderly population (>65) 4 percent, small and marginal land in remote areas, aging, labour shortage and cost, migration, arm conflict
2 Kayah	Aging index 10.8, elderly population (>65) 3.7 percent, small and marginal land in remote areas, labour shortage and cost, migration
3 Kayin	Aging index 14.3, elderly population (>65) 5.1 percent, labour shortage and cost, migration
4 Chin	Aging index 12, elderly population (>65) 4.8 percent, small and marginal land in remote areas, aging, labour shortage and cost, migration
5 Shan	Aging index 13.2, elderly population (>65) 4.3 percent, small and marginal land in remote areas, aging, labour shortage and cost, migration, population growth, urbanization, arm conflict

13.2.2.2 Natural resources and environment pressure on the agricultural production base

State	Challenges and constraints
1 Kachin	Heavy rain and erosion, deforestation, migration
2 Kayah	Declining soil fertility, low precipitation
3 Kayin	Flood, changing rain pattern, rising frequency and severity of natural disasters
4 Chin	Heavy rain, erosion, landslide, declining soil fertility, deforestation, frost
5 Shan	Climate change, soil erosion, declining soil fertility, flood, frost

13.2.2.3 Technical constraints for mountain agricultural production

State	Technical constraints
1 Kachin	Yield gaps, low productivity (labour), low inputs, insufficient supply of quality seed, sustainable practices, slow pace of agricultural mechanization
2 Kayah	Yield gaps, low productivity (labour), low inputs, insufficient supply of quality seed, sustainable practices, slow pace of agricultural mechanization, agricultural mechanization
3 Kayin	Yield gaps, low productivity (labour), low inputs, insufficient supply of quality seed, sustainable practices, agricultural mechanization
4 Chin	Yield gaps, low productivity (labour), low inputs, insufficient supply of quality seed, sustainable practices, slow pace of agricultural mechanization, agricultural mechanization
5 Shan	Yield gaps, low productivity (labour), low inputs, insufficient supply of quality seed, insufficient supply of quality seed, sustainable practices, agricultural mechanization

13.2.2.4 Market, lack of market information, channels, etc.

State	Market access
1 Kachin	Lack of market improved business environment, information and investment along the agrifood supply chain; lack of rural infrastructure to improve smallholder agriculture efficiency and profitability
2 Kayah	Lack of market improved business environment, information and investment along the agrifood supply chain; lack of rural infrastructure to improve smallholder agriculture efficiency and profitability
3 Kayin	Lack of market improved business environment, information and investment along the agrifood supply chain; lack of rural infrastructure to improve smallholder agriculture efficiency and profitability
4 Chin	Lack of market improved business environment, information and investment along the agrifood supply chain; lack of rural infrastructure to improve smallholder agriculture efficiency and profitability
5 Shan	Good market access in most area and has market channels to neighbouring countries (China, Thailand)

13.2.2.5 Physical and infrastructure

State	Physical and infrastructure
1 Kachin	Weak transportation and infrastructure
2 Kayah	Fair transportation
3 Kayin	Good location and transportation for domestic movement and to Thailand
4 Chin	Poor transportation and infrastructure
5 Shan	Good location and transportation to China, Thailand

13.2.2.6 Policy and institutional

The policy and institutional status of the mountain region of Myanmar is typically defined as the capacity to carry out key governance functions including planning, policy formulation and analysis, monitoring and evaluation safeguards are very low. The statistical systems are weak with a lack of value-added agro-industry.

The human resource development and economic reform implementation are also insufficient in the mountain regions.

13.2.2.7 Agricultural institutions in mountain region of Myanmar

To conduct localized experiment and agricultural research activities, provide agricultural extension services and to fulfill needs of agricultural graduates, the agricultural institutions were established in mountain regions as below:

- ◆ 1 Central Agricultural Research Center in Shan state for highland crops
- ◆ 7 Agricultural Research Farms (5 stations in Shan, 1 station each in Kachin and Kayah)
- ◆ 5 State Agriculture Institutes (SAI) (Chin, Kachin, Shan, Kayah and Kayin)
- ◆ 26 District agriculture offices (Department of Agriculture)

- ◆ 96 Township agriculture offices (Department of Agriculture)
- ◆ Other seed production farms and facilities

13.2.2.8 Strengths, Weakness, Opportunity, and Threat (SWOT) Analysis in upland areas of Myanmar

Based on the "Final Assignment Report of Livelihoods and Food Security Trust Fund, 2015", Myanmar's upland area was generally defined as below using SWOT analysis:

Strength

- ◆ Abundance of cultivable "waste land"
- ◆ Provision of seedlings, inputs and technology by state agencies to increase plantation crops
- ◆ MLFD Bank is supporting farmers to a certain extent
- ◆ Small scale pig and chicken farming is feasible to meet domestic needs
- ◆ Land may be available for livestock farming and pasture establishment
- ◆ Favourable climatic conditions for livestock, poultry farming and temperate fruit trees



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Weaknesses

- ◆ Slash and burn practice in **taung ya** cultivation
- ◆ Low acceptance of improved technology by farmers
- ◆ Lack of energy sources and electricity in hilly areas
- ◆ Poor road/ access to market
- ◆ Low crop productivity
- ◆ Financial constraints for practicing improved upland farming practices, locally in **taung ya** adapted improved seasonal crops seeds and expanding livestock production
- ◆ Lack of improved upland farming practices
- ◆ Poor knowledge and skill of management, feeding and raising livestock
- ◆ No/lack of access to veterinary services
- ◆ Animal quarantine is weak by staff and law enforcement is poor
- ◆ Livestock movement controlled by the authorities

Opportunities

- ◆ Increasing access road to border markets of neighboring countries
- ◆ Presence of private sector investment for processing industries such as sugar mills, palm oil mill and rubber in the area
- ◆ Increasing access to Veterinary service for livestock health care
- ◆ Reforestation potentials
- ◆ Good opportunity to export animals and animal products to China, India and Thailand
- ◆ By-product of farm produce in hill areas can be used for small holder commercial livestock farming; livestock and poultry

Threats

- ◆ Increase in deforestation and environmental degradation
- ◆ Incidences of land slides blocking access roads following heavy rain
- ◆ Infectious diseases are endemic
- ◆ Grazing areas are limited
- ◆ Unregulated border trade
- ◆ Some livestock and poultry diseases are endemic

13.3 Opportunities and entry points for mountain agriculture development to address Zero Hunger and poverty reduction

13.3.1 Agricultural diversification and sustainable intensification

Diversify crops from production of staples to mix with Future Smart Foods (FSF) – shift from monoculture to diversified and integrated farming systems, animal production and grazing systems, conservation agriculture, etc.

The cultivation and production methods of staple food crops has shifted – from the tradition slash and burn practice to intensive farming in the last few decades to fulfill growing domestic consumption, especially in Shan, Kayah and Kayin states. The farming system has drastically changed to more intensive farming of marketable crops such as maize and sugarcane, and mixed cropping of food and perennial crops as market access and demand have increased. Consequently, the improper use of pesticides and natural resources in commercial farming (e.g. maize commercial farming in Shan) is threatening the mountain ecosystem.

Furthermore, due to the lack of a farmers' associations and market information, price fluctuations are a major constraint for the development of mountain agriculture.

Many farming systems in the mountain region of Myanmar are based on diverse agro-climates, ethnic groups, culture, socio-economics, transportation and market access. Commercial farming is common in some areas while subsistence farming is more prevalent in remote areas. Visible crop-based commercial farming include:

- 1) Rice intensification (all states)
- 2) Maize intensification in Shan, Kayah, Kayin and Kachin
- 3) Sugarcane monoculture in northern Shan
- 4) Intensive vegetable and horticultural cultivation in southern Shan
- 5) Integrated farming (crop cultivation and animal raising)

13.3.2 Agro-processing activities for agriculture products

- 1) Vegetable processing, storage and marketing in Shan
- 2) Black tea processing (Shan)
- 3) Coffee processing in southern Shan
- 4) Drying services for maize and paddy (Kayah, Kayin)
- 5) Dry vegetable factory in Aung Ban Township, Shan
- 6) Sugar mill (Shan, Kachin)
- 7) Dry elephant yam factory in Chin
- 8) Rice milling

13.3.3 Value-added measures and activities for agriculture products

- 1) Winery (Shan)
- 2) Myanmar GAP certification for highland coffee, tea, mango and vegetables in Shan
- 3) Avocado and mango production groups in southern Shan
- 4) Vegetables, horticulture, floriculture and organic farm groups
- 5) Tea cultivation association
- 6) Organic farming of vegetables in Shan

13.3.4 Social protection measures aimed at mountain people

Myanmar enacted the “Law of Protection of the Farmer Rights and Enhancement of their Benefits” on 8 October 2018 to:

- 1) Support farmers by providing suitable loans and assistance for investment.
- 2) Manage the provision of technology, inputs and production facilities to farmers to improve production.
- 3) Assist farmers to get reasonable prices and markets for selling agricultural produce.
- 4) Protect the rights of farmers with small plots and effectively enhance their benefits.
- 5) Provide aid where possible, for loss and damage caused by natural disasters.

13.3.5 Government intervention to stabilize crop prices

The Rice Federation of Myanmar (MRF) set a basic price (floor price) for paddy in March 2018 to help farmers weather price volatility. This initiative is leading to conserve reasonable price and quality of other major potential crops.

13.4 Country experience

13.4.1 Good agriculture practices on sustainable and integrated farming in mountain areas

As a consequence of the Global GAP and ASEAN GAP, the Ministry of Agriculture, Livestock and Irrigation of the Union of Myanmar launched the Myanmar GAP Protocol and Guidelines in 2017 for 15 crops (avocado, cabbage, coffee, maize, mango, onion, paddy, peanut pepper, pomelo, pulses, sesame squash, tomato and watermelon). For the mountain region, GAP farming and certification are in place for avocado, coffee, mango, sesame and tea in Shan and Kayah.

To enhance the dissemination of advanced technologies and promote the capabilities of extension staff, the Department of Agriculture has formulated a comprehensive programme of “Integrated High Technology Demonstration villages” in every township of Myanmar.

13.4.2 Policy measures and initiatives for sustainable and inclusive mountain development

The Ministry of Agriculture, Livestock and Irrigation prepared an Agricultural Policy in 2016 to guide the implementation of the Second Five-Year Plan (2016–17 to 2021–22) by:

- ◆ Improving food security and safety and the intake of a balanced diet.
- ◆ Ensuring farmers enjoy their rights and benefits from the emerging economic growth.
- ◆ Forming groups or cooperatives of small-scale farmers, livestock keepers and fisher folks (with mandated participation by women) to modernize and improve the performance of the entire sector based on transferred knowledge.

- ◆ Improving smallholder farmer's socio-economic status through a target programme of investment in rural road construction, rural infrastructure development, land use management and small-scale production industry development.
- ◆ Securing much-needed technology and financial assistance from local and external sources to further improve crop, livestock and fish production as well as cooperative development.
- ◆ Enhancing the production of high-quality grain, meat and fish products for external markets.
- ◆ Developing an efficient agro-based industry, including small-scale industries, and associated vocational education.
- ◆ Increasing access to local and external investment for the agriculture sector.
- ◆ Actively ensuring full participation of all stakeholders involved in poverty alleviation, agriculture sector development, and sustainable rural development programmes.

The Government of the Republic of the Union of Myanmar launched the "Agricultural Development Strategy (ADS) and Investment Plan (IP) 2018–19 to 2022–23" in June 2018. The ADS has three objectives that corresponding with the strategic pillars of governance, productivity and competitiveness:

- ◆ Objective 1. Enhanced governance and capacity of institutions responsible for agricultural development.
- ◆ Objective 2. Increased productivity and farmer income.
- ◆ Objective 3. Enhanced market linkages and competitiveness.

The ADS provides the vision, framework and long-term development goals and strategic priorities of the Republic of the Union of Myanmar for sustainable development of the agricultural sector to 2030. The assurances of food and nutrition security as well as livelihood and income enhancement are key objectives of the ADS. The IP for the five years (2018–19 to 2022–23) is an integral component of the ADS that is based on the ADS' (1) vision, impact, outcomes, outputs and suggested activities; (2) recommendations for policy formulation and action; and (3) suggestions for the coordination and implementation and other medium and long-term considerations.

The overall impact of the ADS has five dimensions: (1) increased food and nutrition security; (2) poverty reduction; (3) competitiveness; (4) higher and more equitable income of rural households; and (5) strengthened farmers' rights. The ADS copes with comprehensive approaches and measures guided by the vision and Agricultural Policy (2016) to implement the second Five-Year Plan, specific programmes, project and action plans.

Activities based on the perspectives of mountain agriculture need to be formulated for the mountain region with the participation and initiatives of local government and people as its unique features of biophysical condition, diversity of environment, ethnic groups and culture.

13.4.3 Case study

Shan is the biggest state in the mountain region of the Republic of the Union of Myanmar. A study on the multi-functionality of agriculture was conducted for Inle Lake of southern Shan by the ASEAN-MAFF(Japan) Project in 2003–2006.

The study contained three main functions and eight activities:

- 1) Environment function
 - i) Eutrophication mitigation (water purification) of the floating garden farming system
 - ii) Soil erosion reduction on cropped land in upland sloping areas
 - iii) Flood mitigation in the upstream areas of the lake
- 2) Cultural function
 - iv) Agritourism in Inle Lake
- 3) Food security function
 - v) Case study on Self Sufficiency Rate(SSR)* approach at national level
 - vi) Survey at individual household level in southern Shan
 - vii) Survey of people's perception of food security and risk assessment
 - viii) Provision of agricultural inputs for sloping upland and floating garden areas

* SSR (Self Sufficiency Rate) is indicator (%) for measuring of food sufficiency (Production/Utilization x 100).

Table 13.12 Slope, plot size, and planting dates for each plot of case study in Myanmar

	Site A		Site B		Site C	
	Bare soil	Cropped soil	Bare soil	Cropped soil	Bare soil	Cropped soil
Slope (%)	15	15	15	15	35	35
Plot length (m)	25	25	25	25	22	22
Plot width (m)	3	3	3	3	3	3
Upland rice sowing date		–			4-5-04	4-5-04
Corn sowing date	8-5-04	8-5-04	8-5-04	8-5-04	–	–
Upland rice harvest date	–	–	–	–	25-9-04	25-9-04
Corn harvest date	15-9-04	15-9-04	15-9-04	15-9-04	–	–
Annual rainfall (mm)	996.72					

13.4.4 Case study on soil erosion reduction function in sloping upland area of southern Shan

13.4.4.1 Methodology

Southern Shan is situated in the mountain ranges. Due to the indiscriminant extraction of fuel wood for several years, most of the mountain ranges have become barren with severe erosion. The severe soil erosion and sedimentation from surrounding mountain ranges have reduced the width and depth of Inle Lake. The government has attempted to revitalize the environmental degradation through a reforestation programme around Inle Lake. The project also aimed to increase awareness of the soil erosion problem by providing an education programme and demonstrating soil erosion minimization techniques, as well as improvement of crop productivity.

The project assisted the participating farmers with establishing contour bunds on the sloping sites of project villages in the pilot programme. In total, 7.34 ha of contour bunds were established on farmers' fields. During the programme, the soil erosion reduction function was achieved in two consecutive monsoon seasons in 2003 and 2004. The objectives of the study were to:

- ◆ Determine how much soil is protected with cover crops and non-cover crops on slopes of varying degree
- ◆ Educate farmers on the importance of soil conservation
- ◆ Create awareness of how severe soil erosion causes rapid sedimentation in lakes
- ◆ Measure economic losses caused by soil erosion

Soil loss was measured from soil erosion plots that were either bare or covered with crop. The characteristics of each plot are presented in Table 13.12. Sediment collectors, installed at the bottom of each plot, were 3 m long, 1 m wide, and 0.75 m deep. The surface of the collector was covered with a plastic sheet lining to collect sediment and runoff water. The weight of the collected sediment and volume of runoff water were measured periodically, with sediment samples taken to determine gravimetric water content.

Under real-world conditions, it is rare to find completely bare soil, even on degraded land. Weeds and bushes, to some extent, can significantly reduce erosion, relative to artificial bare plots. In many erosion trials, the purpose of establishing bare plots is to determine soil susceptibility to erosion (soil erodibility) (Wischmeier and Smith, 1978). In this study, comparing erosion from bare and cropped land showed the effectiveness of vegetation for reducing erosion.

The equivalent monetary value of the soil conservation function of the cropped soil was calculated as follows:

$$\text{Economic value of soil conserved} = (\text{Estimated volume of soil eroded in bare soil} - \text{Estimated volume of soil eroded in cropped soil}) \times \text{Cost of contour bund}$$

13.4.4.2 Results

In 2004, the volume of soil eroded was 4.35 mt/ha in cropped land and 8.95 mt/ha in bare soil.

Table 13.13 Soil loss and runoff from bare and cropped plots from adjacent sites with the features described in table 13.12

Data collected/calculated	Site A		Site B		Site C	
	Bare soil	Cropped soil	Bare soil	Cropped soil	Bare soil	Cropped soil
Soil deposit (wet) (kg/plot)	132.00	53.60	168.00	67.20	44.80	22.40
Soil deposit (dry) (kg/plot)	76.95	32.03	80.78	41.03	43.73	24.75
Soil loss (ton/ha/year)	10.26	4.27	10.77	5.47	5.83	3.30
Runoff water (lit/plot)	7 381.00	3 105.00	7 459.00	3 186.00	6 542.00	3 106.00
Soil loss (mm/year)	1.00	0.40	1.10	0.50	0.60	0.30

Estimated volume of soil eroded in bare soil = 194 752 m³

Estimated volume of soil eroded in cropped soil = 94 438 m³

Average cost of construction of contour bund = USD 1.00 m⁻³

Economic value of soil conserved = (194 752 – 94 438) × 1.00 = USD 100 134

13.4.4.3 Conclusion

The economic value of soil conserved by constructing contour bunds to prevent soil erosion amounted to USD 100 314/annum.

13.5 Strategic consideration and suggestions

13.5.1 Policies

The vision for Myanmar agricultural development in 2030 is to have “an inclusive, competitive, food and nutrition secure, sustainable agricultural system contributing to the socio-economic wellbeing of farmers and rural people and further development of the national economy”.

As communities, regions and states become more actively involved in planning and implementing public expenditure, the coordination between local and national plans becomes more important. Myanmar is pursuing different forms of decentralization that the political process will need to define. There is a need to formulate possibilities for innovation in public investment planning where communities, regions and states will play new and significant roles.

Agriculture has changed from subsistence to commercial farming in some mountain areas, where accessibility and market facilities have improved, but most areas still rely on traditional farming practices for their livelihood. Further economic opportunities exist as most of the mountain region is located on the strategic Asian highway network. Factors such as good communications, transportation and trade policy in the future of AESAN +3 communities push to use more resources and this could have an undesirable impact on the environment. To embark on this economic opportunity, Myanmar needs to prepare for the future of mountain agriculture and actively participate with international institutions and entities.

13.5.2 Measures and interventions

New measures and interventions for mountain agriculture development are needed by sharing knowledge and information with international communities, institutions and close collaborations and coordination with development partners, INGOs, CSO and CBO.

13.5.3 Governance

Major constraints and challenges for mountain agriculture development in Myanmar are:

- 1) Lack of targeted mountain-specific strategies or policies at the national level
- 2) Lack of sound statistical systems for evidence-based decisions
- 3) Lack of updated data/information on poverty, food security and nutrition levels of mountain people
- 4) Lack of effective international cooperation and investment
- 5) Lack of special incentives and subsidies.

13.6 Conclusion

Sustainable agricultural development in the mountain region of Myanmar is strongly linked with the environmental process, climate change, prosperity and stability of many ethnic groups and other intangible concerns. Although Myanmar has some success stories when it comes to mountain agriculture, many challenges and constraints remain. An awareness of the role and importance of mountain agriculture needs to be advocated by the public and all stakeholders. Systematic surveys, assessments, plans, programmes, projects, action plans and activities need to be formulated in conjunction with international communities, institutions and development partners, based on the framework of Myanmar Agricultural Development Strategies.

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14 Nepal

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14.1 Overview

14.1.1 About the country

A Physical characteristics

Nepal is located mainly in the Himalayas of Southeast Asia. It lies between latitudes 80° 04' E to 88° 12' E and longitudes 26° 22' N to 30° 27' N, and borders India to the south, east and west, and China to the north. The total land area of Nepal is 56 812 square miles (147 181 km²). The land structure varies from north to south and, accordingly, is divided into three physical regions (ecological regions): mountain, hill and *terai* (plain). The mountains constitute about 35 percent (51 817 km²) of the ecological topography of Nepal, hills make up 42 percent (61 345 km²) and *terai* is 23 percent (34 019 km²). Mountain elevations range from 3 300 to 8 848 m, hills from 610 to 3 300 m and *terai* from 60 to 610 m (Kullabs, 2018). The climate type ranges from sub-tropical monsoon to very cold/freezing. The weather varies from place to place due to its topography. Nepal has diverse natural vegetation, with rich biodiversity of plant and animal species.

B Demographics

According to the 2011 census, the population of Nepal was 26.49 million with an average density of 180 people/km² and an annual growth rate of 1.35 percent. Population distribution ranges from 6.73 percent in the mountains to 43 percent in the hills and 50.27 percent in the *terai*. The 2011 census identified 83 percent of the population as rural and 17 percent as urban.

C Economy

Nepal's economy relies mainly on agriculture, industry and trade. Agriculture accounts for 28.9 percent of the gross domestic product (GDP) and generates direct employment for more than 66 percent of the economically active population (MoALD, 2018).

The 2016/17 financial year recorded the highest economic growth rate (6.94 percent) in ten years (average 4.2 percent); 2014/15 recorded 2.97 percent and 2015/16 only 0.01 percent. According to the 2016/17 Economic Survey, the agriculture sector's share of GDP has gradually declined over the last 15 years, from an average of 34.3 percent (2002/03 to 2006/07) to 34.1 percent (2007/08 to 2011/12) and 31.4 percent (2012/13 to 2016/17) (MoF, 2018).

D Hunger and all forms of malnutrition

Among countries in the South Asian Association for Regional Cooperation (SAARC), the prevalence of undernourishment (PoU) from 2014 to 2016 was highest for Afghanistan (23 percent) and Sri Lanka (22 percent) and lowest for Nepal (8.1 percent). The proportion of undernourished in Bangladesh and India was similar (14 to 15 percent), with these two populous countries accounting for the highest number of undernourished people in the region (Acharya *et al.*, 2018).

The prevalence of stunting and wasting of Nepal was 37.1 percent and 11.3 percent, respectively. The prevalence of underweight in the country was 30.1 percent (Acharya *et al.*, 2018).

E Poverty: population below poverty line

Poverty in Nepal, according to the Nepal Living Standards Survey (NLSS) 2010/11, averaged 25.16 percent across the whole country, with 15.46 percent in urban areas and 27.43 percent in rural areas. Poverty distribution in the five development regions was Eastern (21.44 percent), Central (21.69 percent), Western (22.25 percent), Mid-western (31.68 percent) and Far-western (45.61 percent) (NLSS, 2010/11). Poverty distribution across the different ecological zones was mountain (40 percent), hill (30 percent) and *terai* (30 percent).

14.1.2 Mountainous areas in Nepal

A Physical characteristics and demographics

Mountain areas occupy 51 817 km² or 35 percent of the total land area in Nepal. Sixteen of the 77 districts in Nepal are in the mountains. The mountain region ranges in altitude from 3 300 m to 8 848 m. Nearly 7 percent of the population live in the mountains. The demography of the mountain is changing due to migration to major cities and *terai* regions for better education, employment, health services, quality life, etc.

B Major economic activities and sources of livelihood

The major economic activities in the mountains are agriculture, animal husbandry, medical herb collection and mountain tourism. The sources of livelihood come from these activities and remittances. These remittances are usually sent from foreign countries by Nepalese youth who travel abroad to undertake unskilled and skilled jobs.

C Hunger and malnutrition in mountain areas

Nepal struggles with high levels of hunger and poverty. Poor nutrition and food insecurity have remained a challenge and an impediment to development in Nepal. National surveys in past decades have consistently demonstrated high levels of undernutrition in children: about 36 percent of Nepal's children suffer from stunting, 10 percent from wasting and 53 percent from anaemia. Forty-one percent of women of reproductive age suffer from anaemia and 17 percent from long-term energy deficiencies. These statistics differ by geographical region and social group. The immediate causes of chronic malnutrition in Nepal include limited diversification of crop production, insufficient nutrient intake, dietary patterns, poor communication, poor dietary diversification, lack of water, sanitation and hygiene, poverty and poor nutrition awareness. More women and children suffer from malnutrition than men.

The NLSS 2010/11 found that 38 percent of Nepalese people are living with less than the minimum daily requirement of calories for a healthy life. However, significant disparity prevails between rural and urban areas, ecological zones (mountains, 38 percent; hills, 36 percent; and *terai*, 24 percent), and development regions, ranging from 24 to 36 percent. By development region, the two western (Mid- and Far-western) regions are more calorie deficient than

the three eastern (Eastern, Central and Western) regions. This means that the hilly and mountainous areas of the Mid-western and Far-western development regions are worst hit by food insecurity and insufficient calorie intake (Acharya *et al.*, 2018).

D Poverty

Poverty alleviation became a major objective for Nepal in its ninth five-year plan (1997–2001). Poverty alleviation and the Human Development Index have progressed significantly due to periodic poverty alleviation and social security programmes, and remittance spent on consumption. The population living below the absolute poverty line has declined from 31 percent (1997–2001) to 25.4 percent (2010–2013) to 21.6 percent (2013–2016), with the target set at 18 percent in end of 2016. Most of the Millennium Development Goals (MDGs) have been achieved, and progress toward the Sustainable Development Goals (SDGs) is in process (MoF, 2018). Poverty alleviation is a crosscutting issue and requires a multisectoral approach, with line agencies such as health, agriculture, education, etc. working together.

14.1.3 Contributions and percentage of mountain agriculture

A Land area, type, classification and distribution, and utilization in mountain areas

The hill region occupies about 42 percent of the total land area of Nepal. Comparatively, the hill region has less cultivable land than the *terai* region. The lower slopes are used to produce food crops, such as maize, millet and wheat. Paddy, maize and wheat are produced in the valleys and river basins. Animal husbandry is also a good source of income for people in the hill region. Cash crops such as citrus, ginger, tea and cardamom are also grown. The main occupation of the people in this region is agriculture. Some youth have left for foreign employment. The northern-most region of Nepal is the mountain region. This area occupies about 35 percent of the total land area of Nepal. Due to the difficult topography and cold climate, only 6.73 percent of Nepali people live in the mountain region.

B Population: mountain areas vs. national

According to the 2011 population census, 43.1 percent of the total population in Nepal live in hilly regions and 6.73 percent live in the mountain region.

C GDP: mountain agriculture vs. country

In 2016/17, the agriculture sector contributed 28.9 percent to the GDP. National production from food grains (rice, maize, millet, wheat, barley, buckwheat) was 9 741 000 million tonnes. The mountain region produced barley (32 100 million tonnes) and buckwheat (11 900 million tonnes). Finger millet and beans were also produced in the mountain region. Potatoes and temperate fruits, such as apples, were also produced in the mountain region along with medical herbs. The hill region produced some cereals, potatoes, vegetables, citrus, tea, coffee and subtropical fruits.

D Main mountain agricultural activities and products (crops, livestock, agro forestry)

As mentioned, barley, buckwheat, finger millet and medicinal herbs are produced in the mountains. The potato, barley and buckwheat zone is in the lower range of the Himalayas from 2 500 to 3 500 m above sea level. The land is steep and less fertile than some other zones, and the holdings are small and fragmented. Crops take longer to mature and harvesting one crop annually is common practice. Crop productivity is very low and there is limited scope for intensification to increase yields.

Farmers in the mountain region do not derive their main income from livestock, and neither animal nor crop production can meet their basic needs. Many young people move to lower, more favourable altitudes to farm, or go abroad to find work. Generally, mountain farmers have little or no access to roads, electricity, markets or modern communication systems (Ghimire, 2015).

Agroforestry enterprises include chestnut, walnut, apple, peach, plum, apricot, and fodder plants for animals, e.g., *Chuletro* (*Brassiopsis hainla*) and *Koiralo* (*Bauhenea variega*).

E Income: mountain areas vs. country, sources of livelihood (agriculture vs. non-farm)

Income in the mountain region is lower than the hill and *terai* regions. Crop production is low in this region, and temperate fruit cultivation, livestock rearing, medicinal herbs, tourism and hotels are also sources of income. Some Nepali youth go to neighbouring countries as migrant worker for unskilled and skilled jobs.

14.2 Mountain agriculture in Nepal**14.2.1 Status****A Land utilization in mountain areas**

Of the 14 718 000 ha of land in Nepal, 3 091 000 ha (21 percent) are cultivated for agriculture. About 1 030 000 ha (7 percent) of the agricultural land remains uncultivated. There are 1 766 000 ha (12 percent) of grassland and pasture, 4 268 000 ha (29 percent) of forest, 1 560 000 ha (10.60 percent) of shrubland, 383 000 ha (2.6 percent) are water resources, and 2 620 000 ha (17.8 percent) of land comes under other uses (MoAD, 2015). Land in the mountain areas is barren due to the steep slopes, rough soil and poor irrigation facilities. Cultivation practices are difficult due to the often steeply sloping surfaces.

B Main farming systems in mountain areas

Agriculture in the mountain areas is integrated with animal husbandry. One or occasionally two crops are grown annually. The growing season is longer than in the hill and *terai* regions due to the extremely cold climate. Cropping patterns such as maize–finger millet, buckwheat–barley, and potato–barley are practiced in the area (Ghimire, 2015). Animals including sheep, goat, yak, and *Chauri* prevail in this region.

C Crops commonly grown in mountain areas

The staple food crops are potato, maize, barley, wheat and buckwheat, which are cultivated on the vast rainfed *bari*-lands. Beans (*Phaseolus vulgaris*) are a common pulse crop and are eaten extensively as vegetable dishes or mixed into a *dal*. Apple, walnut, almond, peach, pear and plum are important fruit crops, and cabbage, cauliflower, carrot, radish, potato, green pea, tomato and onion are important off-season vegetable crops. The communities commonly collect medicinal, aromatic plants (MAPs) such as *yarsagumba* (*Ophiocordyceps sinensis*). Other important non-timber forest products (NTFPs) include *sugandhawal* (*Valeriana jatamansii*), *jatamansi* (*Nardostachys grandiflora*) and *panchaunle* (*Dactylorhiza hatagirea*). Pine trees are the main forest trees.

Table 14.1 Overview of mountain agriculture, and food security and nutrition in Nepal

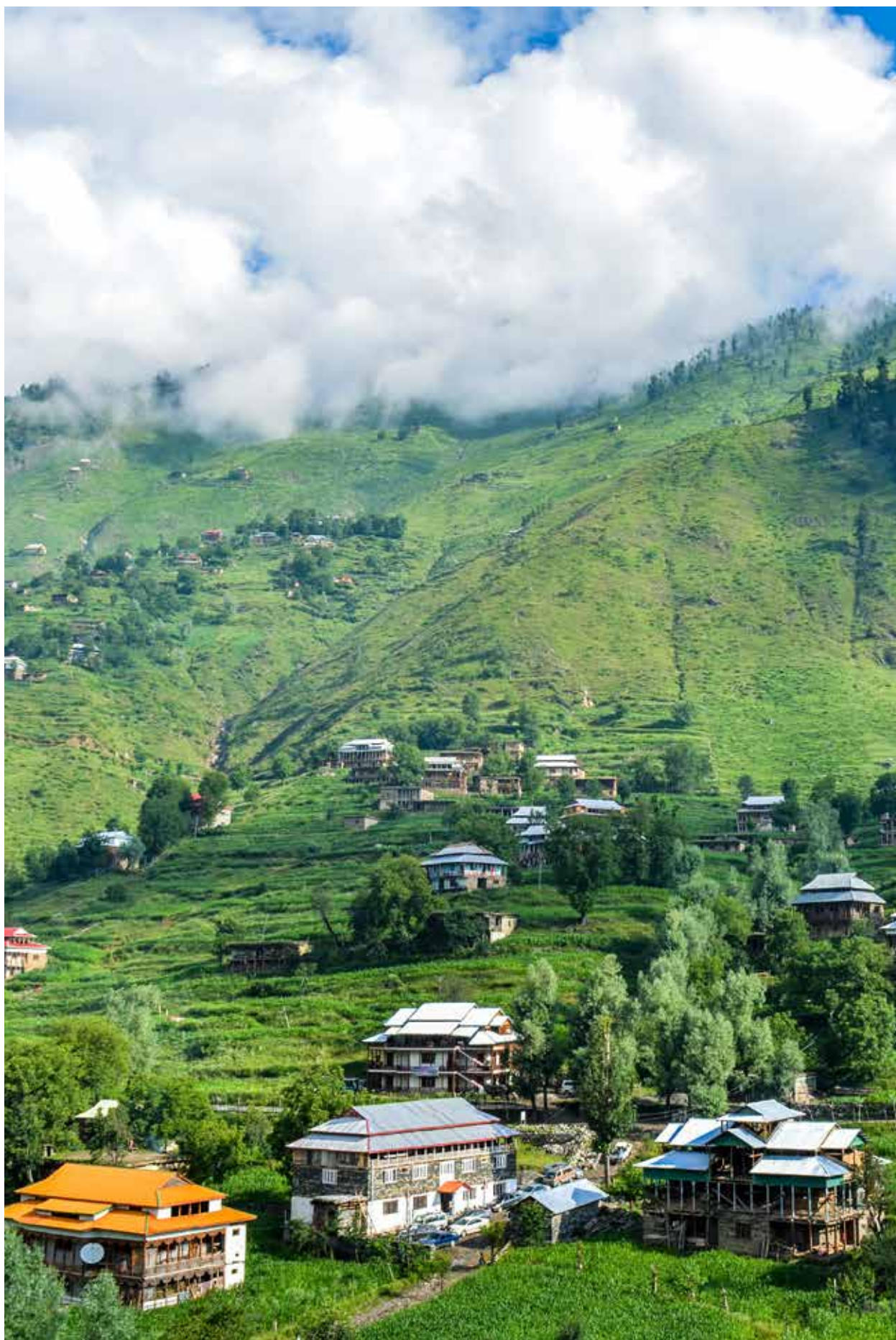
Socio-economic factors	Population	Nation	26 494 504 people
		Mountain areas	1 783 080 people (6.73 percent)
	Food insecurity	Nation	<ul style="list-style-type: none"> ◆ 20% mildly food insecure ◆ 22% moderately food insecure ◆ 10% severely food insecure
		Mountain areas	<ul style="list-style-type: none"> ◆ 18.8% mildly food insecure ◆ 28.9% moderately food insecure ◆ 13.8% severely food insecure
	Malnutrition	Nation	<ul style="list-style-type: none"> ◆ Stunted: 36% of children under age 5 years ◆ Wasting: 10% of children under age 5 years ◆ Underweight: 27% of children under age 5 years ◆ Overweight: 1% of children under age 5 years
		Mountain areas	Not known
	GDP	Nation	28.9%
		Share of GDP of mountain areas in country	Not known
Agro-climatic	Total land/areas in mountain areas		51 817 km ²
	Distribution of mountain land/areas in country: Major regions/districts/provinces		16 districts from north to south
	Land utilization in mountain areas (used vs fallow/wild land)		Covered with forest, grassland and pasture, barren land, agriculture
	Altitude (range)		3 300–8 848 m
	Soil type		Fertile to rough soil
	Rainfall		100 cm
	Crop growing period		Different times for different crops
Agriculture	Main crops		Millet, barley, buckwheat, potato, maize
	Minor crops		Not limited
	Main cash crops		Potato
Forestry	Non-timber products		<i>Sugandhawal (Valeriana jatamansii)</i> , <i>jatamansi (Nardostachys grandiflora)</i> and <i>panchaunle (Dactylorhiza hatagirea)</i>
	Medicinal plants		<i>Yarsagumba (Ophiocordyceps sinensis)</i>

Source: 2016 Nepal Demographic and Health Survey (NDHS), MoH, 2016; MoALD, 2018

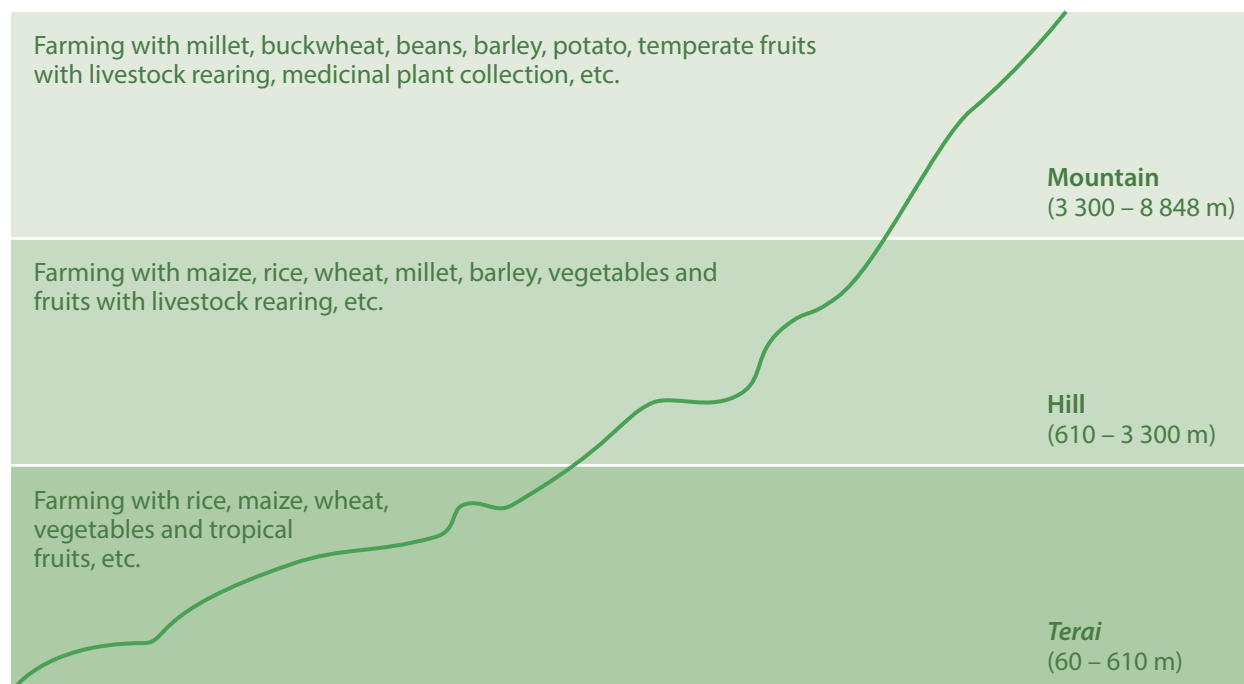
D Animal production and grazing systems in mountain areas

Chyangra goat, *Bhyanglung* sheep, *Lulu* and *Kirko* cattle, *Chauri*, Tibetan horse, yak and *Nak* predominate in the mountain regions. Farmers keep sizable flocks of sheep, goat, yak and *Chauri*. The

grassland area is 1.776 million ha or 12 percent of the land area. Most of the grassland is in the high hills (79.3 percent) and the middle hills (16.7 percent). More than half of the grassland is in the mountains. The *terai* and *Siwaliks* (inner *terai*) together cover 4 percent of the grassland area.



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Figure 14.1 Agro-ecological zones and farming systems in Nepal

14.2.2 Challenges and constraints for sustainable mountain agriculture

A Socio-economic factors

The Constitution of Nepal 2015, Land Use Policy 2015 and National Land Policy (draft under discussion) ensure that constitutional provisions are implemented for land use and land rights. The National Land Rights Forum (NLRF) at the central level and District Land Right Forum (DLRF) at the district level obtained land titles for more than 39 000 landless and tenured farmers, and played a critical role in the introduction of the Joint Land Ownership Policy to establish equal ownership of land for women. The *terai* and hill regions have more issues with land tenure than the mountain region.

B Natural resources and environmental pressure on agricultural production

Agricultural land in Nepal is increasingly being used for other purposes, which has reduced the cultivated land area. Organic matter in the soil is being destroyed, and the soil is becoming more acidic. Climate change is also affecting agriculture: the ecozone crop belt has been changing due to increasing temperatures, changes in the intensity of rainfall patterns, flooding and inundation in plains and valleys, and drought and heavy rainfall. Increased temperatures in mountain areas have affected fruit crops, such as apple, and livestock. Natural disasters

such as flooding, drought and landslides are having an impact on agriculture. Each year soil erosion increases. Forest areas in the mountains are less affected by such factors due to accessibility issues.

C Technical constraints for mountain agricultural production

Due to their remoteness and lack of infrastructure, most mountain areas are underdeveloped. Agriculture is mainly subsistence farming. Projects such as the High Mountain Agribusiness and Livelihood Improvement Project (HIMALI), Agriculture Food Security Project (AFSP), High Value Agriculture Project (HVAP), and Rising Income of Small and Marginal Farmers Project (RISMFP) have supported some districts in different activities. Most activities have been small grants for value chain development, the establishment of small agro-industries, farmers' field schools, infrastructure development (storage for cereals, seeds, potato, fruits, etc.), seed production and marketing support, small irrigation support, market management, and training. The national average productivity per hectare for maize is 2.55 million tonnes, millet is 1.16 million tonnes, buckwheat is 1.06 million tonnes, barley is 1.11 million tonnes, wheat is 2.55 million tonnes, and potato is 13.94 million tonnes (MoALD, 2018). Productivity in the mountains is lower than the hill and *terai* areas.

D Market

Market information is broadcast by radio, television and local private FM radio on a daily basis. Private FM radio has been established throughout the country. The local open market (*hat bazaar*) occurs once a week or fortnight. Farmers sell their produce in these markets. For mountain products like apples and beans, the government of Nepal subsidizes transportation to urban areas. Farmers also transport their products via mules, *Chyangra* goat, yak, etc. The common market channels are producer–wholesaler–retailer–consumer, or producer–retailer–consumer or producer–consumer, depending on the commodity and bulk of production.

E Physical and infrastructure

Road networks are generally poor in the mountain regions though mountain trails (*Ghorato*) are common in this region. There are gravel roads and tracks to district head quarters in most of the mountain districts apart from Humla and Dolpa in the Mid-western development region. Only a few roads to head quarters are linked in the mountain region due to rough topography and the difficulty of building roadways. Apples and potatoes are stored in cellars (zero energy stores) built by farmers using government subsidies. Food grain is stored in houses due to low production levels. Market collection centres are built for storing vegetables. Small irrigation schemes have been constructed in some mountain areas. Dairy collection centres are available for milk collection.

F Policy and institutional

The government of Nepal has prioritized certain mountain areas for agricultural development, particularly the Mid-western and Far-western regions because these zones have remote districts and high levels of poverty (31.68 percent and 45.61 percent, respectively). Non-governmental organizations (NGOs), including international NGOs, are also involved in the food security programme. The District Agriculture Development Offices (DADOs) and District Livestock Services Offices (DLSOs) had effective extension services until 16 July 2018. Agriculture programmes are carried out with farmer groups and agriculture cooperatives for cost-effective and wide coverage. There are about 44 258 farmer groups (DoA, 2017) and 13 221 agriculture cooperatives (out of a total of 34 512 cooperatives) throughout the country (DoC, 2017). The restructuring of the country's administration system into a federal system abolished the government district offices. The newly

established federal government (local government and provincial government) took over the district office responsibilities from 17 July 2018.

14.3 Opportunities and entry points for mountain agriculture development to address Zero Hunger and poverty reduction

14.3.1 Agriculture diversification and sustainable intensification

The government of Nepal started several programmes for improving cereal, vegetable, fruit, legume, milk, meat, fish and egg production. These programmes prioritized crop diversification and the introduction of high-yield varieties. Improved crop varieties and their yields according to Joshi, Bhatta *et al.*, (2016) are as follows:

- ◆ Barley (*jaw*): Bonus Variety (2.8 mt/ha) and Coll-112-14 (2.56 mt/ha)
- ◆ Naked barley: (*Uwa*) *Solu Owa* (1.65 mt/ha)
- ◆ Buckwheat: *Mitha Phapar* (1.23 mt/ha) and *Tite Phapar* (1.15–1.75 mt/ha)
- ◆ Beans: *Trishuli simi* (14 mt/ha) and KBL-3 (1.64–3.01 mt/ha)
- ◆ Proso Millet (*Chino*): *Dudhe chino* (3.5–3.8 mt/ha)
- ◆ Finger Millet (*Kodo*): *Dalle-1* (3.3 mt/ha), *Kabre Kodo-1* (1.83–4.83 mt/ha), *Kabre Kodo-2* (2.53 mt/ha), *Okhle-1* (3.3 mt/ha) and *Sailung Kodo-1* (2.49 mt/ha)
- ◆ Foxtail Millet (*Kaguno*): *Seto Kaguno* (2.5–3.5 mt/ha) and *Kalo Kaguno* (2.5–3.5 mt/ha)
- ◆ Maize: *Ganesh-2* (3.5 mt/ha)
- ◆ Potato: *Kumal Laxmi* (20–25 mt/ha), *Khumal Seto-1* (25 mt/ha), *Khumal Ujjwal* (25 mt/ha), *Kufri Jyoti* (20 mt/ha) and *Janak Dev* (25–30 mt/ha)
- ◆ Rice: some varieties are cultivated in Jumla Valley, Arun Valley and the foothills of mountain districts of Nepal. Improved varieties include *Chhomrong Dhan* (4.2 mt/ha), *Lekali Dhan-1* (4.07 mt/ha) and *Lekali Dhan-3* (3.9 mt/ha)
- ◆ Wheat: *Annapurna 1* (5.5 mt/ha), *Annapurna-2* (5 mt/ha), *Annapurna-3* (5.5 mt/ha) and *Annapurna-4* (5 mt/ha)

Proso Millet (*Chino*)Buck wheat (*Phapar*)Finger Millet (*Kodo*)

14.3.2 Agroprocessing activities for agriculture products

For value-added produce, processing and marketing are important. DADOs in the mountain region support agroprocessing for cereals, fruits and vegetables. The Agro-enterprise Centre (AEC), under the Nepalese Chamber of Commerce and Industries (FNCCI), has supported farmers in the establishment of agroprocessing for small cottage industries; for example, grading apples, making jams and jellies, grinding buckwheat, barley and finger millet to make flour. The flours are in demand at markets due to their nutritious value. The Government of Nepal has helped to establish these processing plants by giving technical and financial support. Mountain products are available in various markets in Nepal and even in some cities.

14.3.3 Value-added measures and activities for agriculture products

The added value of products comes with their processing, with quality control and food safety measures taken into consideration. The agriculture commodities are graded and processed for value addition. The logos of farmer groups, cooperatives, agro-industries and agrofarms are stamped on products for quality assurance. The certification of products is not common due to difficulty in maintaining standards. The government is aware of this and is in the process of rectifying the problems. Some processed products including apples, tea, coffee and medical herbs (e.g. *Yarsagumba*) are exported to other countries. The AEC under the FNCCI coordinates with district industry and trade offices to establish agrobased industries and entrepreneurship. The one village-one product programme, including items such as apples, rainbow trout fish, sweet orange (*junar*), ginger, herbs, etc., according to potential and demand, is implemented with support from the Ministry of Agriculture and Livestock Development (MoALD).

14.3.4 Social protection measures targeting mountain people

The level of social development can be gauged by the status of education, health, sports, women and children, social security, drinking water and sanitation sectors. The concept of human development emphasizes richness and happiness more than economic prosperity. In the United Nations Development Programme (UNDP) *Human Development Report 2016*, Nepal had a 0.558 Human Development Index (HDI), and placed at number 144 of 188 countries. The country has focused on improving education, health, gender disparity, drinking water and sanitation.

14.4 Country experience

14.4.1 Good Agricultural Practices on sustainable and integrated farming in mountain areas

Good Agricultural Practices (GAP) is a comparatively new term for producers and consumers in Nepal, relative to organic agriculture. The Nepal Good Agriculture Practices Implementation Directive 2015 has been drafted and is under discussion for approval; it will act as an umbrella for all GAP schemes in Nepal. The government has assigned the Department of Food Technology and Quality Control (DFTQC) as the

Table 14.2 List of Future Smart Food in the mountain areas of Nepal

Availability of future smart food in mountain areas		Category/ classification: (1) non-timber product; 2) minor crops; 3) main medicinal plants	Type of crops	Nutrients	Altitude (range)	Min temperature (average)	Maximum temperature (average)	Rainfall	Crop growing period
Name of future smart food	Major regions/ districts/ provinces								
Tartary Buckwheat	High hill region*	Minorcrop	Cereal	High rutin	>1 500 m	10	25	100	Summer
Foxtail millet	High hill region*	Minorcrop	Millet	High iron	>2 000 m	10	25	100	Summer
Proso millet	High hill region*	Minorcrop	Millet	High iron	>2 000 m	10	25	100	Summer
Amaranth	Mid hill and high hill regions*	Minorcrop	Cereal	High iron	>1 000 m	10	25	100	Summer
Taro	Mid and <i>terai</i> regions	Minorcrop	Tuber	Vitamin A	>500 m	15	25	100	Summer
Rice bean	Mid and <i>terai</i> regions	Minorcrop	Legume	Protein	>700 m	15	25	100	Summer
Chathelgourd	Mid hill region	Minorcrop	Vegetable		>1 000 m	15	25	100	Summer
Sweet belladonna, Indian poke	Mid hill region	Minorcrop	Vegetable	Vitamin A	>1 200 m	15	25	100	Summer
Nepalese hog plum	Mid hill region	Minorcrop	Fruit	Vitamin C	>1 000 m	15	0.0	0.0	63.3
Nepali butter tree	Mid hill region	Minorcrop	Fruit for oil	Oil	>1700 m	0.0	0.0	60.0	0.0

* High hill means mountain region

Source: Upadhyay *et al.*, (2003); Joshi *et al.*, (2017); Joshi *et al.*, (2018)

Certification Body for Nepal GAP, and a secretariat has been established with representation from the private sector, research institutes and related government organizations.

14.4.2 Policy measures and initiatives for sustainable and inclusive mountain development

The following government policies are for the sustainable development of agriculture.

Agriculture Perspective Plan (APP), 1995–2015

This plan emphasized agriculture development; with the major objectives of increasing the agriculture growth rate from 2.5 percent to 5 percent, and reducing the poverty rate from 49 percent to 14 percent. The mountain areas focused on high-value crops and livestock production, depending on potential.

National Agriculture Policy (NAP), 2004

This is an umbrella policy for overall agriculture development in Nepal. Its aim is to ensure food security and poverty alleviation through high and sustainable economic growth. The specific objectives set in the policy are (1) to increase agricultural production and productivity; (2) to develop a foundation for a commercial and competitive farming system to make the agriculture sector competitive in regional and world markets; and (3) to conserve, promote and properly use natural resources, the environment and biodiversity.

Agribusiness Promotion Policy (ABP), 2006

This policy aims to promote agricultural business to alleviate poverty in Nepal. The policy envisaged the establishment of large production pocket areas, special economic zones (commercial crops or production and organic or pesticide-free production) and an agriproduct export zone.



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Agrobiodiversity Policy (ABDP), 2007

Nepal is richly endowed with agricultural biodiversity, which is on the decline. Realizing the importance of biodiversity for human life on earth, the ABDP relates to the third objective of the NAP (above).

Rangeland Policy, 2010

In the mid-hill and high-hill regions, livestock farming is the main source of livelihood, and range lands are the basis of livestock production. The major objectives of the Rangeland Policy were to upgrade the status of the rangelands to increase their productivity, develop and promote rangeland-based enterprises, and conserve, promote and utilize rangeland biodiversity sustainably and scientifically thereby contributing to the rangeland ecosystem balance.

Agriculture Development Strategy (ADS) 2016–2035

The ADS is expected to guide the agriculture sector of Nepal over the next 20 years. The flagship programmes are the Food and Nutrition Security Program (FANUSEP), Decentralized Science, Technology, Education Program (DESTEP), Value Chain Development Program (VADEP) and Innovation and Agro-entrepreneurship Program (INAGEP), along with the core programmes of Governance, Productivity, Profitable Commercialization and Competitiveness (ADS, 2016).

Prime Minister Agriculture Modernizing Project (PMAMP), 2016–2026

The main objective of the PMAMP is to develop crop-specific areas and value-added commodities that will ensure competition, make agriculture a prestigious job with profit-oriented businesses, create jobs, and coordinate with multi-sectoral line agencies to ensure effective service delivery (PMAMP, 2017).

Case Study

High Value Agriculture Project (HVAP) in hill and mountain areas

Geographical coverage of the project included seven districts: *Achham* (hill), *Dailekh* (hill), *Jajarkot* (hill), *Jumla* (mountain), *Kalikot* (mountain), *Salyan* (hill) and *Surkhet* (hill).

Table 14.3 Beneficiaries in the value chain of social inclusion in Nepal

Value chain programme	<i>Dalits</i> (number)	<i>Jangaties</i> (number)	Others (number)	Total (number)	Percentage (%)	Total women (number)
Apple	194	6	1 869	2 069	13	1 386
Ginger	194	439	822	1 455	9	696
Goat	727	559	2 473	3 759	24	2 519
Off-season vegetables	577	641	2 948	4 166	26	2916
Red pepper (Timur)	503	368	1 334	2 205	14	1125
Turmeric	402	308	1 056	1 766	11	1201
Vegetables	67	11	372	450	3	284
Total	2 664	2 332	10 874	15 870	100	10 099
Percentage (%)	16.8	14.7	68.5			64

Source: HVAP, 2018.

Table 14.4 Sub-project agreements with districts in hill and mountain regions in Nepal

District	Sub-projects	Subsidy amount (NPR in crore)	Sub-project percentage (%)	Subsidy percentage (%)	District category (hill or mountain)
Accham	41	2.23	5.99	3.38	Hill
Dailakh	83	7.56	12.13	11.47	Hill
Jajarkot	83	6.15	12.13	9.33	Hill
Kalikot	97	7.6	14.18	11.53	Mountain
Jumla	84	7.89	12.28	11.97	Mountain
Salyan	65	4.11	9.50	6.24	Hill
Surkhet	231	30.37	33.77	46.08	Hill
Total	684	66.00	100.00	100.00	

Source: HVAP, 2018.

Project Duration: 2011/12 to 2017/18

Project value-chain programme beneficiaries

From Table 14.3, we can conclude that the socially excluded group (*Dalits*) and the indigenous groups (*Jangaties*) are beneficiaries of value chain programmes at 16.8 percent and 14.7 percent respectively. The original beneficiary target was a total of 25 percent of *Dalits* and *Jangaties*, and the overall result was 31 percent. The beneficiaries target for participation by women was 60 percent, and the overall result was 64 percent (HVAP, 2018).

Table 14.4 shows that two mountain districts, *Kalikot* and *Jumla*, had project agreements for 181 of the 684 sub-projects. Mountain districts are also given priority by Government of Nepal for mountain agriculture development.

14.5 Strategic consideration and suggestion

14.5.1 Policies

The NAP 2003 and ADS 2016 promoted sustainable agriculture development through biodiversity conservation, improved soil conditions, soil conservation, seed subsidies, organic fertilizer, sapling distribution and campaigns on sustainable agriculture development. The PM-AMP has been implemented in different regions since 2016/17. There are currently 69 zones and 14 super zones throughout Nepal. In the mountain areas, there are ten districts with zones with over 500 ha for specific crops including cardamom, kiwi, citrus, maize, apple, olive and potato. One super zone with 1 000 ha of apples is in the mountains. The ADS flagship programmes – FANUSEP and VADEP – also support agricultural development in the mountains.

The government has taken the initiative to fulfill the Zero Hunger Challenge by focusing on production programmes to increase productivity and ensure that Nepal is self-sufficient in cereals, vegetables, fish, milk, eggs and meat. The programmes have also focused on increasing farmer income through small-scale agricultural industries. The Constitution of Nepal 2015 (Article 36) declares that each citizen has the right to food.

The Multi-Sector Nutrition Plan I (MSNP I) guided the Government of Nepal to invest in nutrition from 2013 to 2017, and MSNP II (2018–2022) continues to do so. The alignment of the ADS with both the Development Plan and MSNPs I and II is evidence that the government is committed to achieving both agriculture sector development, and food and nutrition security objectives (MoALMC, 2018).

14.5.2 Measures and interventions

The objectives of the implemented programmes by the Government of Nepal aim to make the country self-reliant for food security and nutrition. High-yielding crop varieties, large production pockets, processing, marketing, subsidies for improved seeds and chemical fertilizer, high-value crop production, and local crop production are the major interventions. To protect farmers from natural disasters, crop insurance policies have been implemented. In addition, subsidies and farmer credit are in operation.

Moreover, the Government of Nepal is committed to achieving its development objectives set out by the Constitution of Nepal 2015, 14th Development Plan (2016/17 to 2018/19) and the SDGs, (2016–2030), along with the Agriculture Development Strategy (2016–2035), Nepal Zero Hunger Challenge Nepal Action Plan

(2016–2025), Food and Nutrition Security Plan of Action (2013–2022), Multi-sectoral Nutrition Plan II (2018–2022), and Health Sector Strategy (2015–2020).

14.5.3 Governance

Nepal is a federal democratic republican state. As one of its major features, the constitution (2015) envisages three tiers of government at the state, provincial and local levels with provision for seven provinces and 753 local governments. All three tiers of government are constitutionally assigned exclusive powers along with concurrent powers to be exercised jointly by the federal, provincial and local governments.

14.6 Conclusion

Agriculture in Nepal is substantial and moving towards commercialization. Different agricultural policies over the years have helped to develop agriculture in Nepal and raise the economic status of farmers. The poverty level declined to 21.6 percent as of 2017/18. The country has food deficits in 12 of the 16 mountain districts (MoALD, 2018). Different programmes are in operation to overcome the food deficits. The government has taken steps to fulfill the Zero Hunger Challenge by focusing programmes on increasing productivity and ensuring that the country is self-sufficient in cereals, vegetables, fish, milk, eggs, and meat. The programmes have also focused on increasing farmer income by promoting the development of small-scale agricultural industries. The implementation of policies will help to develop mountain agriculture, achieve Zero Hunger and reduce poverty. The coordination and cooperation of the three tiers of the Government of Nepal are necessary for economic and sustainable development.

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15 Pakistan

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15.1 Overview

15.1.1 Physical characteristics

Pakistan is located within the latitudinal and longitudinal extensions of 24 to 37°N and 61 to 76°E, respectively. Pakistan has an extensive natural resource base, from majestic high mountains (in the Himalaya, Karakoram and Hindu Kush ranges), to inter-mountain valleys in the north and vast, richly irrigated plains in the Indus basin to stark desert in Sindh and Balochistan. The Arabian Sea is to the south, and high mountains (some higher than 7 000 m above sea level) to the northern and western borders. The northern mountains comprise parts of the western Himalayan and Karakoram ranges and a small part of the Hindu Kush range. Pakistan is the only country where three great mountain ranges meet. The western highlands are separated from the northern mountains by the Kabul River and consist of a series of dry and lower hills. Five of the world's 14 tallest mountains (higher than 8 000 m) are in Pakistan. Most of Pakistan's high peaks are in the Karakoram Range including K2. In the Himalayan range of Pakistan, the highest peak is Nanga Parbat, the ninth highest peak in the world. The eastern half of the country is mostly dominated by floodplains of the river Indus and its tributaries: the Jhelum, Chenab, Ravi and Sutlej Rivers. Parts of the Balochistan and Sindh provinces are desert (Hussain *et al.*, 2005).

In Pakistan, almost 61 percent of the total geographical area is mountainous or consists of rangelands (Government of Pakistan, 2013), and these areas have a population of more than 50 million people (Pakistan Bureau of Statistics, 2010). Most of the rangelands are degraded due to increasing pressure from human and livestock populations coupled with frequent droughts. The fragile mountain ecosystem is suffering from degradation of vegetation cover, soil deterioration, and reduced livestock productivity, which have further impoverished the pastoral communities.

15.1.2 Economy

The socio-economic profile of the mountainous areas of Pakistan includes an array of religions, languages, local traditions and festivals. Poverty is prevalent within the mountainous regions of Pakistan, and literacy levels vary, with relatively higher levels in high-altitude areas and comparatively very low in the mountains and rangelands of Balochistan. Women tend to have a significant role in managing day-to-day farming operations in the mountainous areas of Pakistan, while men tend to be involved in a range of on-farm and off-farm activities. For example, circular migration of male labour is quite common in Gilgit-Baltistan, Azad Jammu and Kashmir (AJK), Federal Administered Tribal Areas (FATA) and some areas of Khyber Pakhtunkhwa (KP), while in the Murree and Pothwar regions, a notable proportion of young men join the army for some period or migrate to other countries. Livestock farming in these areas is nomadic and transhumant (moving with livestock seasonally from mountain to lowland pastures).

In recent years, steadily rising temperatures in the valleys of the northern Gilgit-Baltistan region have increased the frequency and intensity of natural disasters. The sustainability of the agriculture sector, a major source of livelihood for thousands of mountain people, is under threat. One farmer reported that wheat productivity on his farm had declined by almost 50 percent in the past five years, with no sign of improving (Jamil, 2015). He said, "erratic rainfall patterns and uncertain weather conditions are one of the 'push-back' factors for me, and I still remember as seven minutes intense rainfall back in 2010 had ruined my near-harvest wheat crop, causing irrecoverable financial loss and hard work of a year in a matter of few minutes" (Jamil, 2015).

15.1.3 Hunger, malnutrition and poverty in Pakistan

Achieving universal food and nutritional security for the growing population has been a core objective of Pakistan's agricultural policies, programmes and strategies since its independence. On 30 June 2011, under the 18th constitutional amendment, the central Ministry of Food, Agriculture and Livestock was devolved in favour of provincial governments. Given the importance of attaining and maintaining national food security and better execution of un-devolved functions, the Ministry of National Food Security and Research (MNFSR) was established by the Government of Pakistan on 26 October 2011.¹ Since its inception, the MNFSR has strived to establish a comprehensive National Food Security Policy, but the lack of countrywide food-security-related information has been a major constraint. Instead, the Task Force on Food Security Analysis was created to conduct a unique countrywide baseline survey on food and nutritional security, and its report is expected soon.

Pakistan is currently facing numerous agriculture and food security, investment, and research-related challenges that are being tackled through a comprehensive strategic framework, involving various policy requirements and implementation strategies. After passing the approval formalities, the first National Food Security Policy was launched by the Government of Pakistan through the MNFSR on 29 May 2018. The vision of the first National Food Security Policy is to achieve "A Food Secure Pakistan". The Policy's mission is "to ensure a modern and efficient food production and distribution system that can best contribute towards food security and nutrition, in terms of availability, access, utilization, and stability". More specifically, the food security policy aims to:

- ◆ alleviate poverty, eradicate hunger and malnutrition;
- ◆ promote sustainable food production systems (crop, livestock, and fisheries) with an average growth rate of 4 percent per annum; and
- ◆ make agriculture more productive, profitable, climate resilient and competitive.

This policy delineates several food security challenges faced by Pakistan agriculture, including those pertaining to "Sustainable use of natural resources (land, water, rangelands, pastures, and forests)" and "Capitalizing the

potential of mountain agro-ecological zones", which are directly and indirectly related to mountain agriculture. It recognizes the fragility of mountain agriculture and the need for the "promotion of integrated watershed management for livelihood improvement in mountainous areas" (Government of Pakistan, 2018b).

15.2 Mountain agriculture in Pakistan

15.2.1 Contribution of mountainous regions to the production of high-value agricultural commodities

The contribution of mountainous regions to the production of high-value agricultural commodities in Pakistan cannot be ignored. Some examples are:

- ◆ In 2016–17, Balochistan Province produced significant amounts of various fruits and nuts, including cherry and pistachio (100.0 percent in area and prod.), grapes (98.9 percent in area and 98.8 percent in prod.), almond (98.4 percent in area and 95.4 percent in prod.), apple (91.5 percent in area and 86.0 percent in prod.), apricot (89.0 percent in area and 93.1 percent in prod.), pomegranate (78.2 percent in area and 71.3 percent in prod.), plum (57.8 percent in area and 53.2 percent in prod.), date (54.5 percent in area and 41.2 percent in prod.), peach (39.3 percent in area and 23.5 percent in prod.) and chikoo (37.1 percent in area and 46.6 percent in prod.) (Government of Pakistan, 2018a).
- ◆ In 2016–17, Khyber Pakhtunkhwa Province also produced significant amounts of various fruits and nuts, including persimmon and walnut (100.0 percent in area and prod.), pear (88.2 percent in area and 96.5 percent in prod.), peach (60.4 percent in area and 76.1 percent in prod.), fig (50.0 percent in area and 74.6 percent in prod.), loquat (45.7 percent in area and 58.3 percent in prod.), plum (41.8 percent in area and 46.4 percent in prod.), apple (8.1 percent in area and 13.4 percent in prod.) and apricot (10.8 percent in area and 6.7 percent in prod.) (Government of Pakistan, 2018a).
- ◆ FATA and Gilgit-Baltistan's combined shares in apricot, cherry, fig, mulberry, and walnut were 37.2 percent, 53.0 percent, 24.5 percent, 77.1 percent and 46.6 percent, respectively (Rasul *et al.*, 2014).

¹ The establishment of the Ministry of National Food Security and Research meant it was perhaps the first ministry of its kind in the world tasked with achieving universal food security for its population. In other countries, food security is a division of the Ministries of Agriculture. For instance, Sri Lanka has the 'Ministry of Agriculture, Forestry and Food Security', Tanzania has the 'Ministry of Agriculture, Food Security and Cooperative', and Mauritius has the 'Ministry of Agro Industry and Food Security'.



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It is unfortunate that few value-added products are locally produced from these valuable horticultural commodities. Developing agricultural value chains using a cluster approach could improve farmer returns from these items, which would help to increase their income and purchasing power, and alleviate poverty.

15.2.2 Farming problems in mountainous areas

Mountain agriculture has some inherent constraints including remoteness and inaccessibility,² marginality and fragility in terms of moisture stress and poor soil conditions, and different crop production seasons than the plains. Mountain areas also face socio-economic constraints including smallholdings,³ poor productivity,⁴ poor production management, labour shortages, poor post-harvest management, poor access to markets and

marketing, and a lack of entrepreneurship. Collectively, these constraints culminate in the underutilization of the agricultural resource base and limited marketable surplus.

With few exceptions, mountain farmers face numerous challenges for improving the productivity of field and horticultural crops. These include, poor orchard management practices, poor quality of planting material and other inputs, poor access to markets and market information, and minimal access to post-harvest processing, value addition and extension services.⁵ These farmers also face feed and fodder shortages as the rangeland vegetation and grasslands have a poor carrying capacity. Farmers report substantial reductions in vegetation cover and due to invasive plant species. Moreover, land erosion due to heavy rains and flash floods is quite common at high altitudes.

² Shahbaz *et al.*, (2010) surveyed farmers in the Mansehra and Swat districts and reported an average distance of 0.82 km between farm houses and arable land.

³ Shahbaz *et al.*, (2010) surveyed farmers in the Mansehra and Swat districts and reported that more than 70 percent of farmers had only 1.25 acres of agricultural land.

⁴ Shahbaz *et al.*, (2010) in their study in Mansehra and Swat districts reported average yields for wheat, maize, potato, barley and rice of 0.48, 0.50, 5.04, 0.60, and 0.70 tonnes/acre, respectively.

⁵ Shahbaz *et al.*, (2010) reported an old farmer of a village saying "I am 64 years of age and I have never seen a single person from Agriculture Department in our village". Another farmer from a village in Swat angrily said that "they (Agriculture Officers, etc.) only take care for the big farmers of plain areas, and as our village is remote and inaccessible so they never come to us". A potato grower said "The yield of our potato crop had reduced to half within the last two years due to some unknown disease. We went to the agricultural office after traveling four hours, but no one was there to guide us. Next week we went again, but the officer was not competent enough to give us a solution to our problem". In a focus group interview, members of the village development committee demanded an effective agricultural extension service for their village so that the growers of persimmon and peach could increase crop yields and profit.

Reaching farmers and community members in mountain areas has always been difficult for agricultural extension workers and researchers. The mountainous areas of most countries are usually among the least developed regions, with mountain communities largely depending on farming for their subsistence. At the same time, factors such as harsh weather, long distances, scattered population, and underdeveloped infrastructure hamper agricultural productivity in these areas.

The literature review established a link between poverty and natural resource degradation, and suggests that poverty could be reduced by improving the quality of the natural resources. There is evidence that empowering farmers to conserve and rehabilitate natural resources helps to reduce poverty through more effective mobilization of local farming communities (Farooq *et al.*, 2007). Likely problems for community mobilization are highlighted in Farooq *et al.* (2007) with remedial measures.

Harsh and unfavourable working conditions, and the absence of suitable incentives often discourages officials from various departments (e.g. forest, agricultural extension, livestock and dairy) from accepting jobs in mountainous areas. The hardship allowance is meagre, given the nature of the working environment. Moreover, there are limited funds available for mountain projects because planning and development authorities, generally, do not prioritize projects that do not meet the criteria for direct economic returns (Farooq *et al.*, 2007).

15.2.3 Institutional support available to mountainous areas of Pakistan

Numerous institutions at international, federal, regional, provincial and local levels are involved in carrying out R&D-related activities to improve conditions in the mountainous regions of Pakistan. International organizations include the International Centre for Integrated Mountain Development (ICIMOD), World Food Programme (WFP), FAO, International Union for Conservation of Nature (IUCN) and United Nations Environment Programme (UNEP).

At the federal level, the institutions involved include:

- ◆ Pakistan Agricultural Research Council in mountainous regions⁶ various outstation institutes/centres,
- ◆ Pakistan Council for Research in Water Resources,

- ◆ Pakistan Meteorological Department, and
- ◆ Soil Survey of Pakistan.

At the provincial institutions include:

- ◆ Agricultural Research Station, Seenlasht, Chitral
- ◆ Provincial Departments of Agriculture
- ◆ Provincial Departments of Agricultural Extension
- ◆ Provincial Departments of Water Management
- ◆ Provincial Departments of Livestock and/or Dairy Development
- ◆ Pakistan Forest Institute, Peshawar, and
- ◆ Provincial Department of Fisheries.

Prominent provincial and local academic institutions include:

- ◆ Agriculture University, Peshawar;
- ◆ Faculty of Agriculture, Abdul Wali Khan University, Mardan;
- ◆ Faculty of Agriculture, Gomal University, D.I. Khan;
- ◆ Faculty of Life Sciences, University of Swat;
- ◆ Faculty of Life Sciences, Karakoram International University;
- ◆ Department of Agriculture, Faculty of Sciences, Hazara University, Mansehra;
- ◆ Department of Agriculture, Shaheed Benazir Bhutto University, Sheringal, Dir;
- ◆ Balochistan Agriculture College, Quetta, and
- ◆ Lasbela University of Agriculture, Water, and Marine Sciences.

Civil society organizations/rural support programmes include: the

- ◆ Agha Khan Development Network, mainly through the Agha Khan Rural Support Programme,
- ◆ Sarhad Rural Support Programme, and
- ◆ Terich Area Development Organization.

In addition, some organizations are work in mountainous areas, including:

- ◆ International Partnership for Sustainable Development in Mountain Regions (Mountain Partnership), Development Communications Network (DEVCOM-Pakistan),

⁶ For instance, Mountain Agricultural Research Center (MARC) Juglote; Mountain Agricultural Research Outstations of PARC at Skardu, Astore and Chilas; Summer Agricultural Research Station of PARC at Khaghan; National Tea and High Value Crops Research Institute, Shinkari, Mansehra; Balochistan Agricultural Research and Development Center (BARDC), Quetta; Horticultural Research Institute at Khuzdar; Agricultural Research Institutes at Turbat, Jafarabad, Barkhan at Rakhni.

- ◆ Focus Humanitarian Assistance Pakistan,
- ◆ Mountains and People,
- ◆ Mountain Areas Conservation and Development Services,
- ◆ National Integrated Development Association (NIDA-Pakistan),
- ◆ New World Hope Organization, and
- ◆ Swat Youth Front.

It is unfortunate that the contribution of the above institutions is only evident in small areas of various mountainous regions. The dream of mountain agriculture in Pakistan reaching its true potential has yet to be realized.

15.3 Challenges and constraints on food security and nutrition in mountainous areas of Pakistan

15.3.1 Significance of poverty and food security in mountainous areas of Pakistan

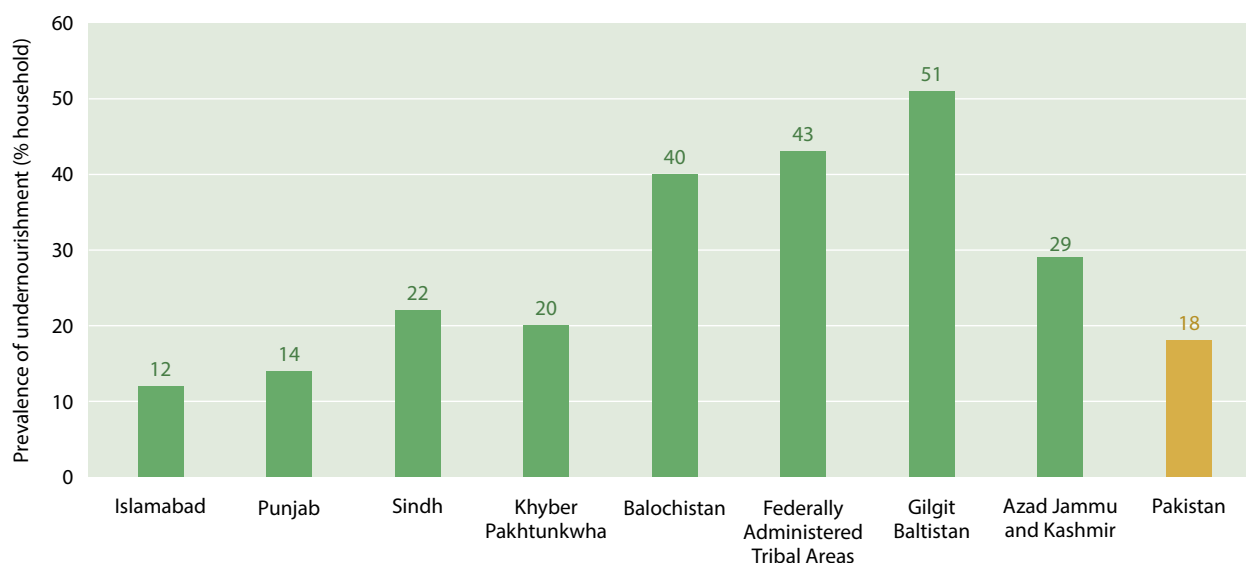
The governments of developing countries, in general, tend to concentrate on development planning and service provision in lowland areas – the centres of national economic production – leaving the poverty and development issues of mountain regions unaddressed. In other words, the issue of food security and its specifics in mountainous regions are often neglected in national and international science and policy agendas. After the adoption of Chapter 13 of Agenda 21, “Managing fragile ecosystems: sustainable mountain development”, at the 1992 UN Earth Summit, awareness of the importance of mountainous ecosystems and communities increased and was reinforced in 2002, which was the International Year of Mountains, and the International Mountain Partnership formed by FAO. International Mountain Day is now celebrated on 11 December each year, with “Mountains Matter” being the theme for the 2018 celebrations. Despite the significant transition in the past two decades of local food production and distribution systems, subsistence agriculture in mountainous regions remains the economic mainstay. The current dynamics are characterized by livelihood diversification with increased off-farm income opportunities, and an expansion of external development interventions (FAO, 2003; Dame and Nusser, 2011).

Considering food security in the context of mountain environments – in addition to their general characteristics of remoteness, political marginalization, low market integration, and limited agrarian resource potential – hidden hunger and the impact of seasonality on diet are also pronounced. Statistical data on health and nutritional indicators in these regions are rarely available; the available data is either at a national level or estimates, aggregates or extrapolations for mountainous areas (Kreutzmann, 2001 and 2006). Few studies report on acute or chronic malnutrition and reduced birth weights in high mountainous environments. Some studies have highlighted nutritional deficiencies such as protein-energy malnutrition and lack of micronutrients (Jenny and Egal, 2002). Frequently, case studies in these regions are based on anthropometric indices to evaluate a prevailing situation (e.g., for the Indian Himalayas: Dutta and Pant, 2003; Dutta and Kumar, 1997). Dietary diversity is another indicator of food security (Faber *et al.*, 2009; Hoddinot and Yohannes, 2000).

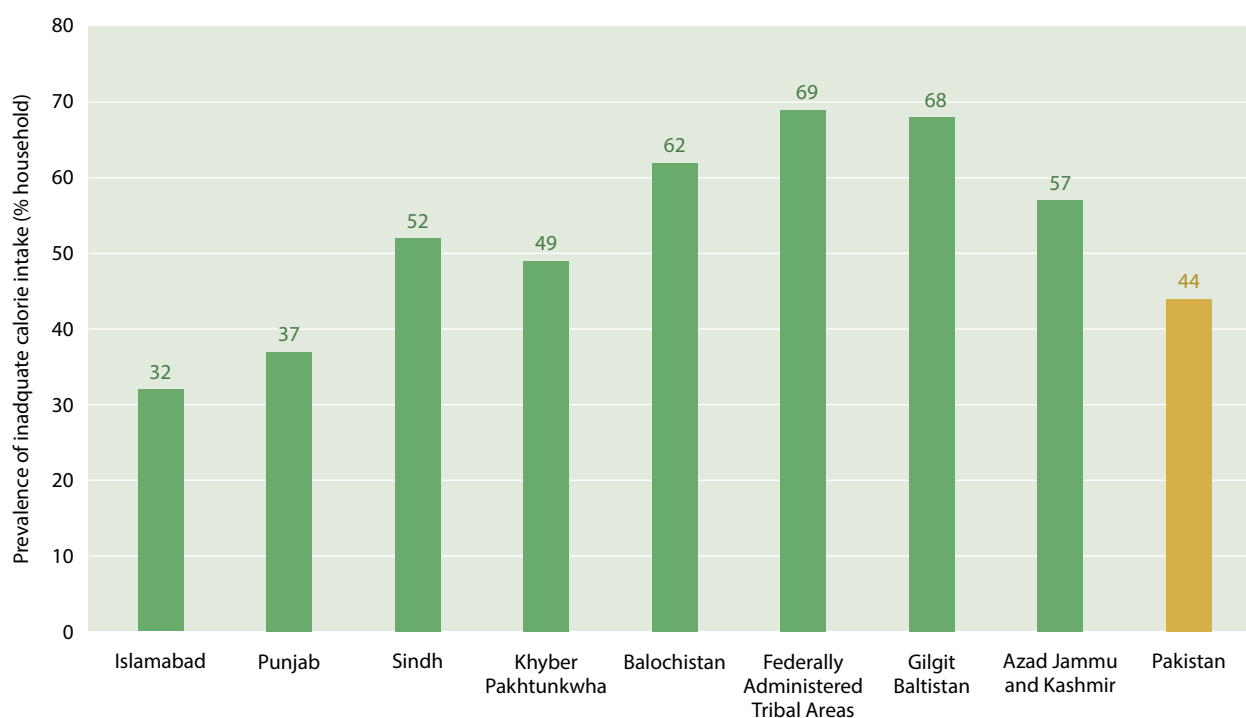
In the last two decades, Pakistan has made significant progress in achieving food security. The per capita food dietary energy availability is now close to the recommended level. However, variation in topographic, socio-economic, and physical conditions exist, such that the situation is not uniform across the country. The challenges of ensuring food security are more daunting in mountainous areas due to the limited amount of arable land, harsh climate, difficult terrain and unfavourable biophysical conditions characterized by inaccessibility, fragility, and vulnerability. Mountain areas generally have higher levels of poverty and food insecurity than the plains and experience increased outmigration of men and the rising role of women in agriculture. The issues are further exacerbated by the impact of climate change (Rasul *et al.*, 2014).

15.3.2 Food security status in mountainous areas of Pakistan – Preliminary findings from food security analysis survey of MNFSR

As previously discussed, the Government of Pakistan has prioritized achieving food and nutritional security for its population since the country’s independence. This role has become more specific since the establishment of MNFSR in 2011. The Ministry felt the need for a countrywide food-security-oriented baseline survey so that the impacts of various policy and non-policy measures could be monitored. In 2012, MNFSR launched the

Figure 15.1 Prevalence of undernourishment across regions in Pakistan

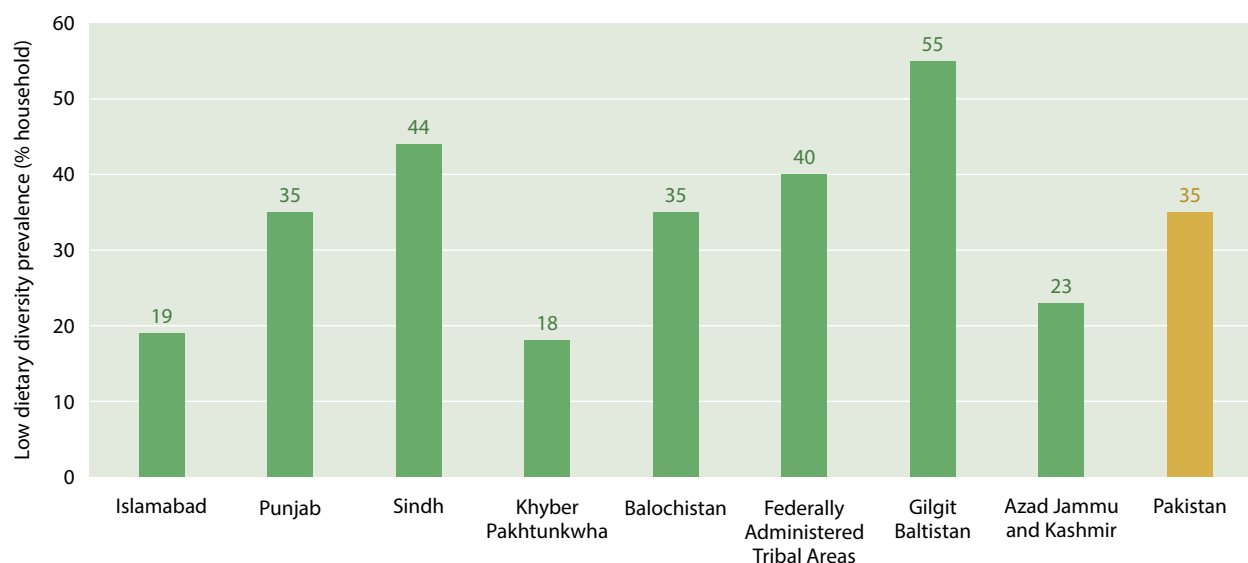
Source: FSA, 2016 (Draft report)

Figure 15.2 Regional distribution of households in terms of adequate calorie consumption in Pakistan

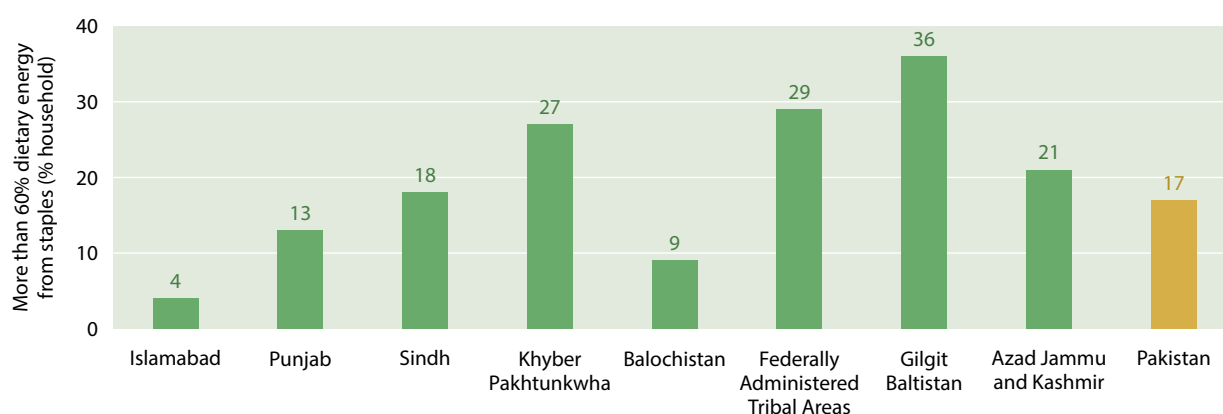
Source: FSA, 2016 (Draft report)

National Zero Hunger Initiative. Further, a Task Force on Food Security Analysis (FSA) was founded in collaboration with several national and international institutions and a multi-disciplinary team of experts. Some preliminary findings of the task force are cited here from the perspective of comparing food and nutritional security in mountainous areas with other regions of Pakistan.

- ◆ Based on the prevalence of undernourishment (PoU) methodology adopted by FAO, the FSA-2016 survey data revealed that 18 percent of the country's population is currently undernourished, with a rural and urban distribution of 17 percent and 22 percent, respectively.

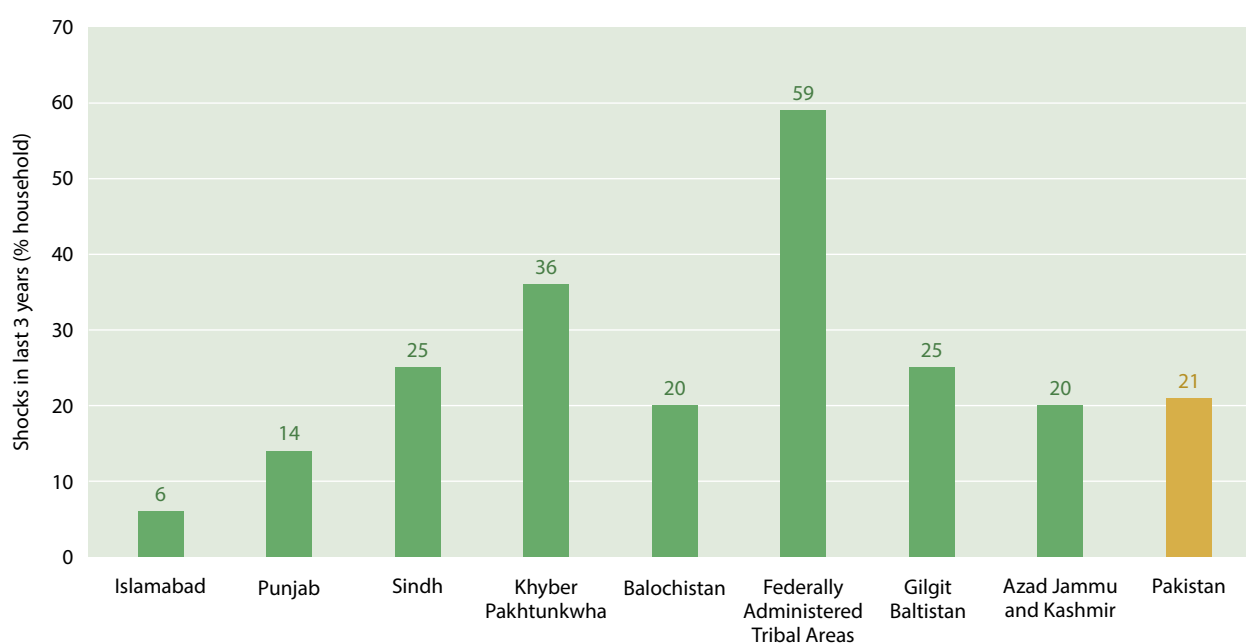
Figure 15.3 Regional distribution of households in terms of the prevalence of low dietary diversity in Pakistan

Source: FSA, 2016 (Draft report)

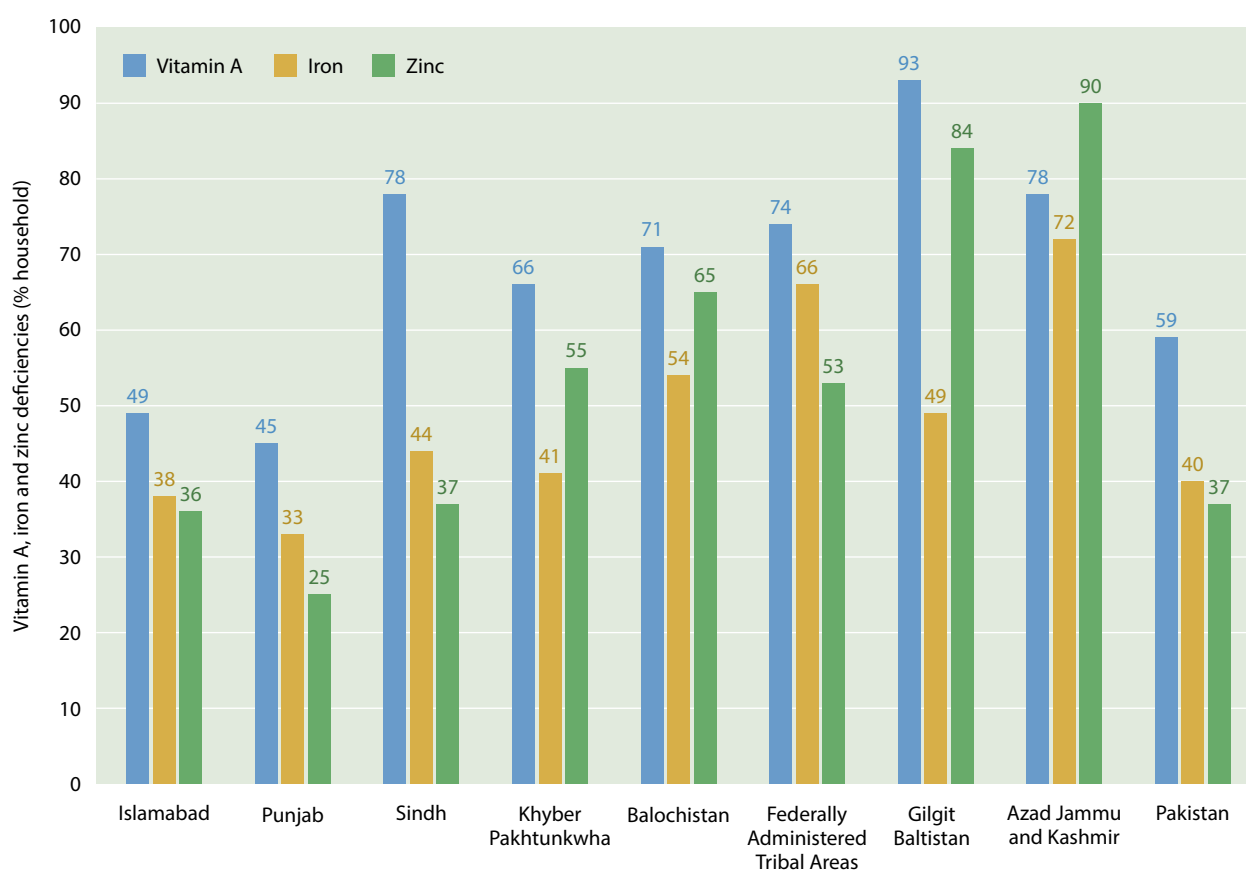
Figure 15.4 Regional distribution of households deriving more than 60 percent of their dietary energy from cereals in Pakistan

Source: FSA, 2016 (Draft report)

- ◆ Large differences in undernourishment were evident between regions, with the range from the highest at 51 percent in Gilgit-Baltistan and the lowest in Islamabad at 12 percent (Figure 15.1).
- ◆ Using adequate calorie consumption at the recommended level of 2 350 kcal per adult equivalent per day, about 44 percent of Pakistani households consume fewer calories than recommended.
 - ◆ Regional estimates had a range with the highest prevalence of inadequate intake in FATA at 69 percent and the lowest in Islamabad at 32 percent (Figure 15.2).
- ◆ The Household Dietary Diversity Score is an indicator of the nutritive value of food: overall, 35 percent of households consumed low dietary diversity, which was confined to a few food groups.
- ◆ Regional estimates for low dietary diversity prevalence have the highest rate in Gilgit-Baltistan at 55 percent and the lowest in Khyber Pakhtunkhwa at 18 percent (Figure 15.3).
- ◆ The diet quality indicator is the share of dietary energy obtained from different food groups. The average Pakistani derives his/her dietary energy from cereals, with 17 percent of households deriving more than 60 percent of their total dietary energy from staple cereals.
 - ◆ Regional estimates for the prevalence of deriving more than 60 percent of dietary energy from cereals ranges 36 percent in Gilgit-Baltistan to 9 percent in Balochistan and 4 percent in Islamabad (Figure 15.4).

Figure 15.5 Regional distribution of households that have experienced a natural disasters or adversity in the last three years in Pakistan

Source: FSA, 2016 (Draft report)

Figure 15.6 Regional distribution of households consuming less than the recommended level of vitamin A, iron and zinc in Pakistan

Source: FSA, 2016 (Draft report)

- ◆ Overall, 21 percent of the households reported experiencing natural disasters or adversity (e.g. flood, drought, earthquake, insecurity, etc.) in the past three years, which affected their food security.
 - ◆ Regional estimates had the highest percentage of households that reported experiencing natural disasters or adversity in FATA at 59 percent, far above the next highest at 36 percent in Khyber Pakhtunkhwa, with the lowest region being Islamabad at 6 percent (Figure 15.5).
- ◆ Overall, the percentages of households that consume below the average estimated requirements of vitamin A is 59 percent, iron is 40 percent, and zinc 37 percent
 - ◆ Regional estimates for diets deficient in vitamin A were highest at 93 percent in Gilgit-Baltistan and lowest at in Punjab at 45 percent (Figure 15.6).
 - ◆ Regional estimates for diets deficient in iron ranged the highest in Azad Jammu and Kashmir at 72 percent to the lowest in at 33 percent in Punjab (Figure 15.6).
 - ◆ Regional estimates for diets deficient in zinc were highest at 90 percent Azad Jammu and Kashmir and lowest at 25 percent in (Figure 15.6).

In summary, a regional comparison of the above-described food insecurity parameters indicates that, apart from Islamabad, households in provinces with mountainous regions (Balochistan, Khyber Pakhtunkhwa, FATA, Gilgit-Baltistan, and Islamabad) are relatively more food insecure, have less diverse diets and derive most of their dietary energy needs from cereals than other provinces. Household diets in mountainous regions are also deficient in vitamin A, iron and zinc. In other words, food insecurity and malnutrition are significantly higher in the mountainous areas of Pakistan than other regions of the country.

15.4 Opportunities and entry points for Zero Hunger and poverty alleviation

The agricultural resource base available to mountainous farming communities in Pakistan is relatively poorer in terms of quantity, quality, and access to critical inputs such as water and purchased inputs (e.g. farm machinery services, fertilizers, pesticides/insecticides). Considerable opportunities exist for enhancing the production of high-value agricultural commodities, i.e. fruits, vegetables, nuts and animal-based products,

which can be harnessed by adopting cluster-based value chain approach. However, there is a lack of efficient marketing linkages, market information and infrastructure required for cluster-based value chain development. While it is encouraging that literacy and education levels are reasonable in the mountainous regions of Pakistan, (apart from many areas of Balochistan province), this can result in the migration of educated youth searching for employment opportunities in Pakistani cities or abroad, and others either temporarily or permanently moving to other areas of the country, leaving the family females and school children to undertake the farming duties.

Institutional support is available for mountain dwellers, but most of these institutions operate in isolation or are confined to small pockets that are inaccessible to most. Provincial rural support programmes, which are endeavouring to connect with mountain farmers, have not had significant impact. In order to rejuvenate and improve farming in mountainous areas, a multidimensional approach with institutional collaboration is needed. To achieve zero hunger in these areas, agricultural diversification, such as the production of high-value agricultural commodities (to gradually reduce cereal-based farming) through cluster-based agricultural value chain development, is needed. This could involve:

- ◆ Identification of viable production clusters of various promising horticultural commodities to initiate value chain development through primary and secondary levels of value addition⁷ at the local level.
- ◆ Identification of various projects/schemes to develop the necessary infrastructure for promoting end-to-end cluster-based agricultural value chains in mountainous areas.
- ◆ Provision of more efficient marketing opportunities, such as agromarketing services in different parts of the country, introduction of assembly markets, credit facilities for mini-trucks, establishment of accessible gasoline stations, and introduction of small-sized packaging industries.
- ◆ Promotion of raw and value-added products from mountainous areas using attractive packaging, branding, labelling, along with classifications such as being organic.
- ◆ Introduction of beekeeping to produce quality honey as a sideline activity for farmers, in addition to increasing the productivity of horticultural crops.

⁷ For instance, the introduction of improved methods of harvesting fruits and vegetables, incorporating value adding fruits, such as solar drying of persimmon, apricots, plums, dates, figs, and for tomato, potato, onion and garlic, etc.

- ◆ Introduction of certified nurseries as promising enterprises for youth to supply quality plants of various fruits and nuts to local farmers.
- ◆ Development of well-integrated, climate-smart animal pastoral production and grazing systems in rangelands.

15.5 Suggestion: Policy support and initiatives for achieving Zero Hunger and poverty alleviation

The Government of Pakistan is committed to realizing the SDGs, both at the federal and provincial levels. Within this framework, achieving zero hunger is a top priority for Pakistan, in the pursuit of SDG 2 pertaining to “ending hunger, achieving food security and improved nutrition and promoting sustainable agriculture”. To achieve Zero Hunger in mountainous areas, various policy support and initiatives are needed as described below.

Institutional and Policy Support:

- ◆ **Food security:** Institutionalize specialized teams to focus on achieving Zero Hunger in provincial agriculture ministries that will engage, coordinate and collaborate with various national, international institutions and civil society organizations (e.g., provincial rural support programmes) in Zero-Hunger-related R&D activities.
- ◆ **Quota for development projects:** Allocate specific quota to develop mountainous and rangeland areas and the value chains for their agricultural commodities in R&D projects in provincial and federal planning and development departments/ministries.
- ◆ **Involvement of local communities:** Involve the representatives of local communities in the planning and implementation of various development policies, programmes and activities. Local communities should also be involved in monitoring, evaluating, revising and refining the plans/programmes.
- ◆ **Mountain and rangeland communities:** Allocate specific quota for departmental promotions and scholarships/education stipends for the children of government officials serving in various departments in mountainous areas and the rangelands.
- ◆ **Institutional financing:** Provide financial support through Zari Taraqiati Bank Limited⁸ (ZTBL) and other commercial banks for farming inputs and to facilitate the adoption of modern agricultural practices.
- ◆ **Marketing potential as organic produce:** Most of the high-value agricultural commodities produced in mountainous regions are health-safe and organic, but are sold as ordinary farm items rather than being marketed as health-safe organic products. Development of an organic certification system for field, horticultural and livestock products is suggested for various clusters in the mountainous regions of Pakistan.
- ◆ **Linking the farmers to markets:** Establish assembly markets at various link-road junctions so that farmers from different villages can bring their marketable surplus to sell to traders/assemblers in a competitive environment.
- ◆ **Information communication technologies (ICT):** Strengthen the agricultural marketing information system by registering growers of high-value agricultural commodities to share daily prices of various commodities via short-messaging and social media.
- ◆ **Mountain agriculture development network:** Establish mountain agriculture development network at the country level and integrate it with similar networks at the regional and international level.

Socio-economic improvement and employment opportunities:

- ◆ **Regional networking:** Develop network of electronic, print and social media to create awareness and experience sharing among farmers for the most effective utilization of agro-natural resources.
- ◆ **Local networking:** Mobilize farmers' networks to organize themselves for collective causes directly/indirectly affecting their resource productivity, sustainability and livelihoods.
- ◆ **Farmers' field schools (FFS):** Establish farmer and pastoralist field schools and women empowerment programmes to transfer technologies and skills for key challenges faced by local communities.

⁸ Previously, it was named as Agricultural Development Bank of Pakistan (ADBP). The present name is the Urdu Translation of ADBP.

◆ **Agricultural support services:**

- ◆ **True-to-type plants:** Develop the capacity of local fruit plant nurseries, including their registration and regulatory control to increase the availability of true-to-type certified plants to farmers in the mountainous areas of Pakistan.
- ◆ **Horticultural value chains:** Small and medium agroprocessing industries should be encouraged to invest in value adding, e.g. solar drying, preparation of various value-added products.
- ◆ **Capacity building:** Train farmers and agricultural workers in improved methods of harvesting, grading and primary value addition to control post-harvest losses of agricultural commodities produced in the area.
- ◆ **Livelihood support activities:** Introduce activities such as kitchen gardening, domestic poultry farming, honeybee keeping and preserving/value adding of medicinal plants as sideline activities for farming households.

Natural resource management:

- ◆ **Successful replantation:** Introduce and promote improved rainwater harvesting and fencing techniques for successful plant rehabilitation in mountains and rangelands.
- ◆ **Sustainable carrying capacity of mountains rangelands:** Involve the local community in controlled grazing of rangelands to sustain the carrying capacity of rangelands.
- ◆ **Soil and water conservation:** Introduce soil and water conservation techniques (to control soil erosion due to heavy rains) using appropriate vegetation coverage and other techniques.
- ◆ **Leguminous crops in cropping systems:** Incorporate leguminous crops into farming systems, as they are not only a good source of vegetative protein, but help to improve soil fertility. Pulse production would also improve local food security.
- ◆ **Climate-change-resilient agriculture:** Introduce field and horticultural crop varieties that are high yielding, pest- and disease-resistant, and climate-change resilient, and which preserve the biodiversity of the area.
- ◆ **Weather and climate-change risks and uncertainties:** Promote diversification in cropping patterns to minimize the risk of crop failure due to weather and climate change.

Food and Feed Security:

- ◆ **Food and feed security:** Introduce improved methods for food storage and the preservation of herbs and shrubs as animal feed to be used in winter.
- ◆ **Food subsidies:** Provide food subsidies for wheat flour and its transportation to poor people in remote areas.

Livestock Productivity:

- ◆ **Livestock feeding programme:** Introduce an improved livestock feeding programme to increase livestock productivity using improved feeding and grazing methods. Provide prepared animal feeds (e.g. conventional concentrates, minerals and molasses blocks (UMMB), mineral mixtures) to farmers at subsidized prices.
- ◆ **Selection breeding:** Promote selection breeding for diverse mountain environments and tolerance to climate change.
- ◆ **Community breeding:** Establish livestock community breeding with herders and pastoralists to replace unproductive animals with productive ones.
- ◆ **Climate-smart integrated production system:** Develop climate-smart integrated crop–livestock–rangeland production system to effectively utilize natural resources.
- ◆ **Protected agriculture:** Promote protected agriculture to intensify production of high-value crops and increase water-use efficiency and production efficiency per unit area in mountain agriculture.

Research and capacity development:

- ◆ **Research and development:** Fine-tune the R&D agenda of provincial and federal research institutes and academia to conduct problem-solving research.
- ◆ **Resilience capacity:** Develop the resilience capacities of farming communities to floods, erratic rainfall, snowfall, etc.
- ◆ **National Disaster Management Authority (NDMA):** Enhance the role of the NDMA by establishing early warning systems and sharing unusual changes in the weather forecast with local communities.
- ◆ **International Mountain Day:** Organize events and workshops for International Mountain Day on 11 December to promote the sustainable development of mountain agriculture.

Strengthening regional and international cooperation:

- ◆ The challenges, constraints and problems facing mountain agriculture are similar between countries with minor regional differences. The challenges and problems faced by mountain ecosystems and mountain agriculture are often complex, trans-boundary and difficult to resolve by a single country or institution. The following forums could be used to promote regional and international cooperation.
- ◆ South–south cooperation to learn about success stories in other countries.
- ◆ Develop R&D partnerships with FAO, ICIMOD, CGIAR, Mountain Partnership, ICARDA, and other relevant institutions.

15.6 The way forward

Globally, the agriculture sector is now considered more than a simple supplier of food/fibre and employment opportunities for the growing population. It is an active partner in economic activities leading to overall development. To implement the above-mentioned policy and development initiatives, they should be prioritized as short-, medium- and long-term plans/policies, and be integrated with micro- (commodity cluster and/or rural households' levels), meso- (district/provincial government levels) and macro-level (MNFSR and Planning Commission level) plans/programmes. Local traditions, social norms and religious concerns should be given due consideration.

Governance issues generally prevail in most public departments, more so in departments such as forest, livestock and dairy development, and mountainous agricultural research and development. Special measures are needed to improve governance in these departments.

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16 Viet Nam

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16.1 Overview

16.1.1 Viet Nam in context

Viet Nam, located in Southeast Asia (8–24° N, 102–110° E), has a natural land area of 331 212 km² and more than 3 400 km of coastline. The Vietnamese Government categorized the country's topography into three main parts (Northern, Central and Southern), with each part divided into two ecological regions (see Table 16.1).

Agroforestry and fisheries occupy 26.8 million ha of Viet Nam, accounting for 81 percent of the total land area (Ha *et al.*, 2016). The varied topography makes the country rich in biodiversity, ranked 16th in the world. The ecological system has about 16 500 plant species and 10 500 animal species, with endemic plants accounting for 30 percent of the plant species.

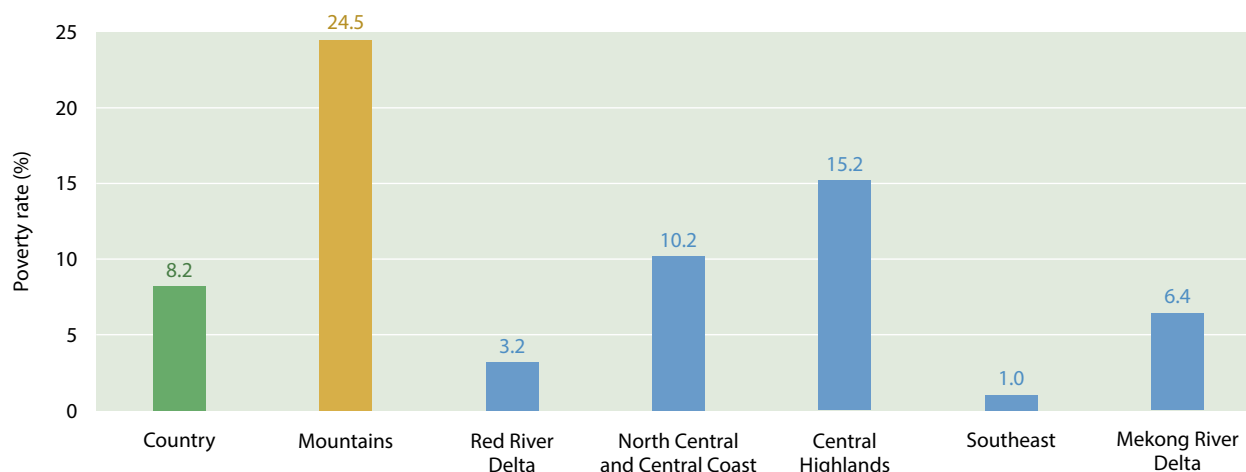
The current population is about 96.6 million people with a density of 320 people/km² (Dan So, 2018), or six times the world average (CIA, 2018). There are 54 ethnic groups in Viet Nam, with the Kinh group accounting for 86 percent of the total population (Tung *et al.*, 2017).

In 2017, Viet Nam's gross domestic product (GDP) was about USD 217.6 billion, ranking 49th in the world (Statistics Times, 2018). The GDP per capita was about USD 2 267 person/year. Services made the largest contribution to the gross GDP (41.32 percent), followed by industry and construction (33.34 percent), agriculture (15.34 percent), and production tax minus product subsidy (10 percent). In terms of GDP composition, the agricultural sector is much larger than the world average of 5.9 percent (CIA, 2018), and employs more than 40 percent of all workers in Viet Nam.

The overall poverty headcount rate in Viet Nam declined from 20.7 percent in 2010 to 9.8 percent in 2016 (Pimhidzai *et al.*, 2017). Some areas, including the Red River Delta, Mekong Delta, and the Southeast region have eliminated hunger (MOLISA, 2017), but hunger or food insecurity remains high from a world perspective, with concentrations in rural and remote areas. According to the UN (2015), the hunger rate has fallen in most provinces but increased in the Northern Midland and Mountainous region from 2010 to 2015.

Table 16.1 Six ecological regions of Viet Nam

	Regions	Physical characteristics
Northern	Northern Midland and Mountains	9.5 million ha, with six Northwest provinces and nine Northeast provinces. Strongly divided mountain ranges, most of which are near the Northwestern border.
	Red River Delta	2.1 million ha, with 11 provinces. Considered the industrial centre of Viet Nam. Surrounded by low hilly terrain, which is denser and more mountainous in the Northwest.
Central	North Central and Central Coast	9.56 million ha, with 15 provinces. Steep slopes in a west-east direction and long coastlines.
	Central Highlands	5.4 million ha, with five provinces. Flat plateaus at high altitude but less slope.
Southern	Southeast	2.35 million ha, with six provinces. Slightly sloped and flat.
	Mekong River Delta	4.08 million ha, with 13 provinces. Flat and combined with coastal areas.

Figure 16.1 Multi-dimensional poverty rate in 2016 by region in Viet Nam

Source: MOLISA, 2017

From 1990–1992 to 2014–2018, the malnutrition rate in Viet Nam declined by 79 percent, the fastest decline in Asia (FAO, 2016). However, the proportion of people considered at risk of malnutrition remains high at 11.4 percent, particularly among pregnant women and children under five (Nguyen *et al.*, 2011). Malnutrition is a nationwide burden, causing up to 24.6 percent of children under age 5 to be stunted, 14.1 percent to be overweight and 6.4 percent to be delayed in terms of growth (NNI, 2017).

16.1.2 Northern Midland and Mountainous region

The region consists of 15 provinces across 100 965 km² or about 28.7 percent of the country. Currently, this region accounts for about 36 percent of the national forest area and is home to more than 70 percent of the total plant and animal species (Quy, 2015).

Socio-ecosystem diversity is the core of the region, which is reflected in the diversity of terrain–soil–microclimate, species, ethnicity, culture, and traditional farming systems (So, 2003). The region has a high sloping terrain, which is sharply divided and complex. According to Phuong and Ton (2017), 85 percent of the area has sloping land with many high mountain ranges integrated with valleys, from the highest mountain (Fansipan at 3 142 m) to the Hoa Binh Valley (20 to 30 m above sea level). This topography creates diverse climates with forest vegetation and crops adapted to different elevations. The climate ranges from tropical and subtropical to temperate, and even to tropical monsoon. The monsoon climate is distinct: the southwest monsoon in summer is notably hot and dry with heavy rain, while the northeast monsoon in winter is cold and dry with less rain.

The regional population is about 11.9 million people, or 13 percent of the whole country (GSO, 2018). The population density is low with an average of 126 people/km², with 82 percent in rural areas. These areas are inhabited by 30 ethnic groups, including H'mong, Thai, Dao, Tay, Nung, and Kho Mu, each with their own cultural characteristics and farming practices (So, 2003, Schliesinger, 2015). In the lowlands, the Tay, Hoa, and Nung ethnic groups are typically concentrated on the left bank of the Red River, with Thai and Muong on the right bank and across to the Ca River. The Dao mainly live on mountainsides at 700 to 1 000 m, while the H'mong reside in the highlands.

The Northern Midland and Mountainous region have experienced significantly faster GDP growth than the country overall. In 2012, the GDP of the region reached 9.64 percent compared with just over 5 percent for the whole country (Hoa, 2013). However, the per capita income of the region remained low at 1.6 million VND/month, or 61 percent of the average income for Viet Nam (GSO, 2018).

This region has a high rate of poverty and hunger. In 2016, the proportion of poor households in mountainous areas was 24.5 percent (northeast 17.7 percent and northwest 31.2 percent), about three times higher than the country's average of 8.23 percent. Of the 15 northern provinces, three have extremely high rates of poverty: Dien Bien (44.8 percent), Son La (31.9 percent), and Ha Giang (38.8 percent) (MOLISA, 2017). The challenges associated with this poverty are the lack of production resources, market instability, natural disasters and epidemic diseases.

Table 16.2 Socio-economic status of Viet Nam

	Population (million)	Prevalence of severe food insecurity (%)	Prevalence of undernourished people (%)	GDP (USD billion)
Nation	92.69	2.30	10.80	217.6
Northern Midland and Mountainous region	11.98	6.45	30.30	19.2

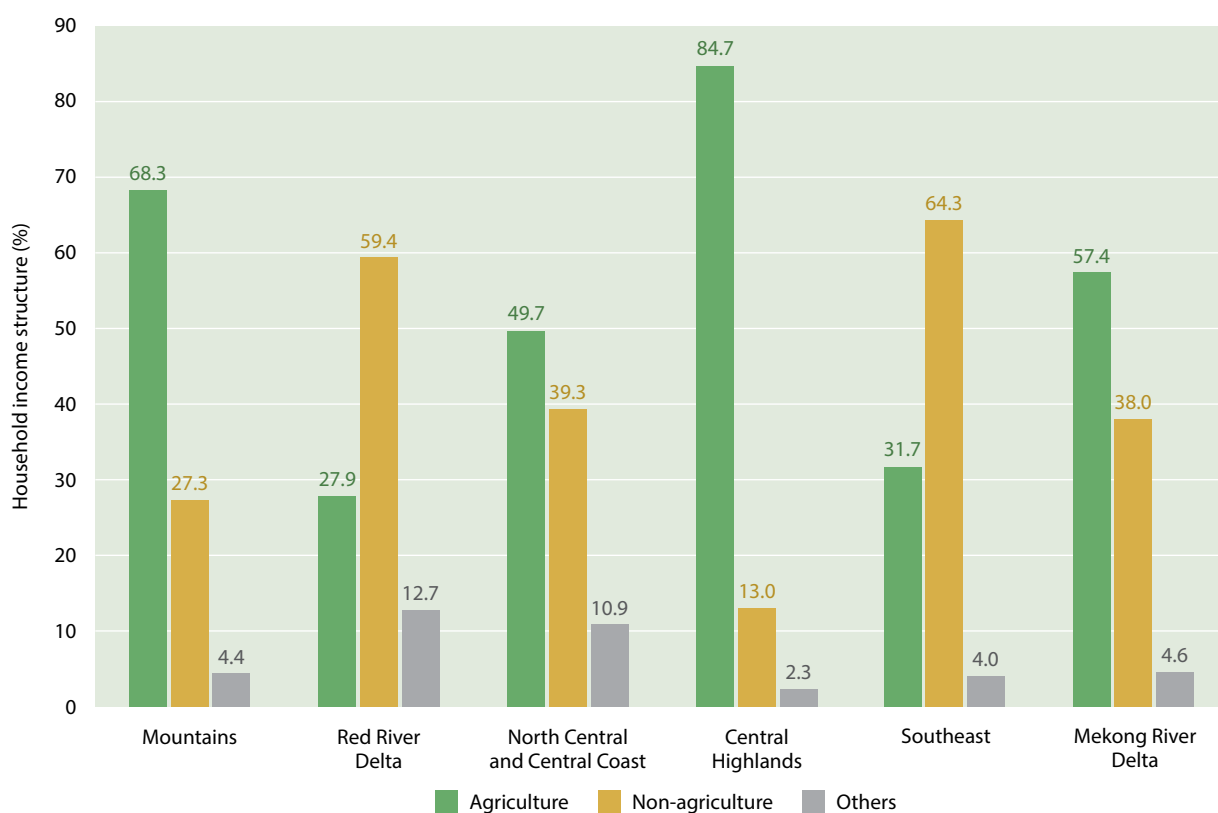
Source: FAOSTAT, 2018, GSO, 2018

Table 16.3 Agro-climatic conditions in Viet Nam and the North

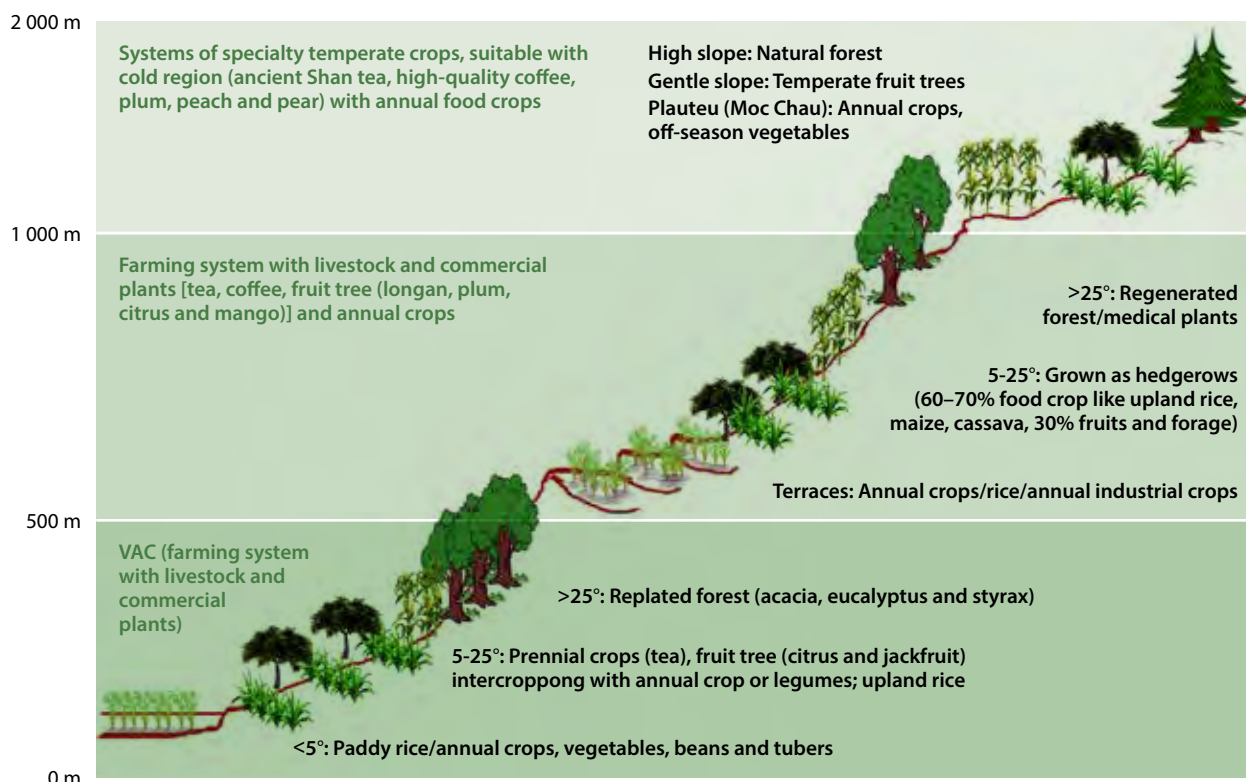
	Land area (Mha)	Fallow land (%)	Altitude (m)	Latitude (N)	Longitude (E)	Topography	Min temp.*	Max temp.*	Annual rainfall (mm)	Crop growing period
Country	33.1	6	–	8° 30' to 23° 22'	102° 10' to 109° 30'	45% slope	15–24	25–31	1400–2400	April–October
Northern Midland and Mountainous region	9.5	14	50–800	20° 18' to 23° 23'	102° 9' to 108° 0'	75% slope	12–16	26–28	1200–2000	April–October

* Average temperature in the coldest and hottest months

Source: GSO, 2018, ISPONRE, 2009, Van, 2015

Figure 16.2 Household income structure by region in Viet Nam, 2015

Source: GSO, 2016a

Figure 16.3 Main farming systems by elevation in the Northern Midland and Mountainous region in Viet Nam

Source: Authors summarised from a NOMAFSI survey

16.1.3 The role of agroforestry in the Northern Midland and Mountainous region

The agricultural sector contributes about 30 percent of the total GDP of the Northern Midland and Mountainous region, about twice the national rate (GSO, 2019). In terms of household income structure in the region, the agricultural sector contributed 68.3 percent in 2015, ranking second behind the Central Highlands (GSO, 2016b). Non-farm activities contributed only 27.3 percent and trade 4.4 percent to household incomes. This confirms the key role of agroforestry for production and economic development in the Northern Midland and Mountainous region. While a large proportion of households in the region are involved in agroforestry activities, forest products, a potential strength of the region, have not been exploited. Of the 75.4 percent of households engaged in agroforestry, only 0.93 percent are involved in forest production.

16.2 Agriculture in the Northern Midland and Mountainous region

16.2.1 Status of agricultural production in the Northern Midland and Mountainous region

The total land area for agriculture, forestry and fishery production in the Northern Midland and Mountainous region is 7.6 million ha (27.8 percent of the whole country), of which 2.1 million ha is used for agriculture, 5.4 million ha for forestry, and 43 000 ha for aquaculture. The average agricultural area per person is 0.138 ha. The large areas of natural forest and abandoned land are advantageous for raising cattle. However, most of the cattle in this area are free-roaming, with only small areas available for forage production. For example, forage production areas are only 0.5 percent of agricultural land in Dien Bien, 0.5 percent in Lai Chau, and 4.2 percent in Lao Cai.

The diversity of topography, slope, climate and farming practices in the mountainous areas supports a range of farming systems, which can be grouped by slope and elevation (Figure 16.3).

Table 16.4 Common crops of the Northern Midland and Mountainous region in Viet Nam

Crop	Harvested area (ha)	Annual production (Mt)	Advantages	Disadvantages
Rice	683 000 (8.8% of the country)	3.3 (7.6% of the country)	High-quality local rice varieties account for about 30% of the total country high-quality rice production	Issues for cropping management: Burning straw, over-use of fertilizers and pesticides
Maize	509 500 in 2016 (44%)	1.9 (36%)	Suitable soil conditions and large area available; area increased by 184% from 2002 to 2016	Sloping, steep land with unsustainable farming techniques, including clearing, burning, and heavy dependence on nitrogen fertilizers causing soil erosion and soil degradation
Cassava	114 600 in 2016 (20%)	1.5 (13.7%)	Low input cost requirement compared to other food crops, thus, suitable for small poor households	Lowest productivity of all regions
Fruit trees	163 000 (21%)		Diverse ecological sub-zones are suitable for numerous tropical, subtropical and temperate fruits	Small scale with lack of technology, market access, inputs and highly dependent on climate conditions
Tea	131 500	1.023	Unique climate and soil conditions are suitable for high-quality tea, especially Shan tea at high elevation	Food hygiene and safety are the biggest constraints; soil protection measures needed on sloping land

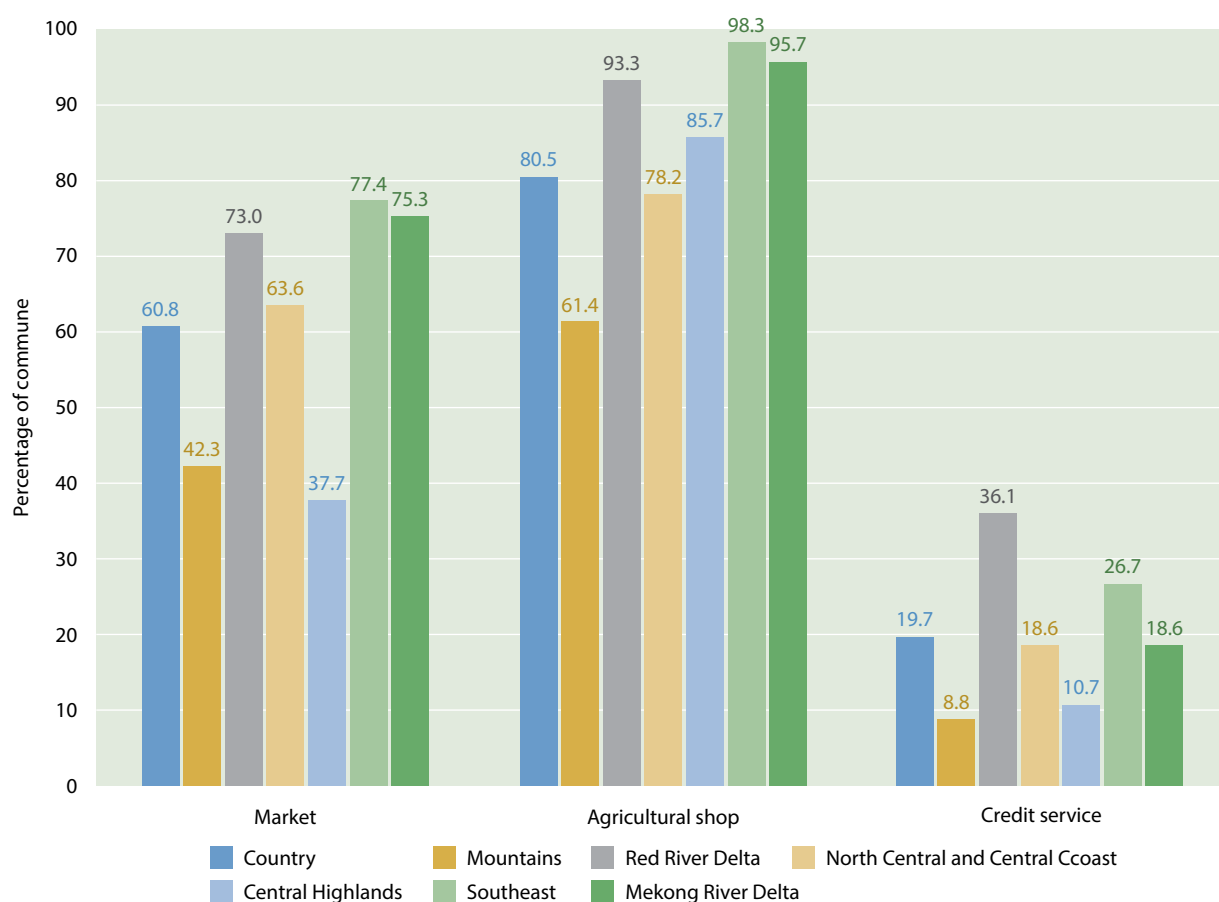
In the Northern Midland and Mountainous region, food crops such as rice, maize and cassava are important for food security. Rice is usually grown along riversides and on terraced fields. The region's diverse natural conditions allow for many types of specialty rice to be grown in this area. However, obsolete farming practices combined with overuse of chemicals mean that production of rice is very low and unsafe. Maize and cassava have a common feature of being able to be grown on sloping land, but unsustainable farming practices make maize and cassava production a major cause of soil degradation and erosion. In contrast to food crops, tea appears to be a highly suitable crop and can contribute greatly to soil protection. In particular, high altitude areas with a suitable chilling temperature are very good for high-quality Shan tea varieties. Fruit trees also have been increasingly used to take advantage of diverse natural conditions, especially temperate fruit trees that can generate significant income to the local farmers.

Livestock in the region is mainly raised by small households on numerous small-scale farms. By 2016, the 2 331 livestock farms in the region were mainly raising buffalo, pigs, poultry, and fish. The approximately 1.4 million buffalo in the region account for 56 percent of the national buffalo headcount. Cattle raising is mainly free-grazing and controlled semi-grazing. As a result, cold winters and associated lack of feed are the main causes of mass death. There are about 7.1 million pigs in the region (only 30 percent of households have more

than 10 pigs). Breeding facilities and caring regimes are below acceptable standards. The use of veterinary drugs, especially antibiotics, and waste treatments are often inadequate. In 2013, just 2.6 percent of livestock households had biogas tanks and 10.5 percent produced compost for waste management (MONRE, 2014). The region hosts 65 to 75 million poultry; there are problems with breed quality, food, disease prevention and waste treatment, which affect quality, productivity, economic efficiency and environmental pollution.

16.2.2 Challenges and constraints for sustainable mountainous agriculture

By 2016, not all provinces in the region had completed issuing certificates for land-use rights to farming households, with only 38 percent issued in Dien Bien. The lack of a land-use right certificate prevents investments in production, especially credit loans associated with production enterprises. Inadequate education is another constraint to the uptake of advanced production technology. The illiteracy rate, is particularly high among ethnic groups. For example, the illiteracy rate among H'mong people aged above 15 is 54 percent and Thai is about 18 percent, while the national illiteracy rate is only 1.5 percent. This issue reflects the challenge related to low-quality labour in the region.

Figure 16.4 Percentage of communes within regions that have agricultural development support services in Viet Nam

Source: GSO, 2016a

Climate change issues have affected regional agricultural production, with unpredictable weather, extreme and damaging cold periods, prolonged heat, concentrated heavy rain, and longer droughts becoming more common. The number of households at risk of being severely affected by climate change in the region is the highest in the country, with 65 to 75 percent in the Dien Bien and Lao Cai provinces, compared with 15 to 25 percent in provinces outside the region (UNU-WIDER, 2017). Under the average emission scenario (RCP4.5) for the region, forecast temperatures will increase by about 0.5°C by 2020 and 1.2 to 1.3°C by 2050, and rainfall will increase by 1.4 to 1.6 percent by 2020 and 3.6 to 3.8 percent by 2050, relative to average figures from 1980 to 1999. Conversely, rainfall in the dry season will decline and the prevalence of drought, heavy rain, and very cold and damaging cold will increase (Thuc *et al.*, 2016).

Isolated agricultural land generates difficulties for technical application and irrigation. Small-scale agriculture land together with isolated transportation in the region make the application of cultivation

technologies difficult and require higher input costs with lower competitive values for products. For example, maize is sown on the largest area in the region, but yields are 53 to 78 percent less than other regions. Being isolated, the Northern Midland and Mountainous regions lack access to agricultural support services, including appropriate markets, suppliers and fund providers. Only 42.3 percent of communes have markets compared with 60.8 percent in the whole country (Figure 16.4); the lack of strong markets affects the value chain with a weaker capacity for cross-border consumption, commodity circulation and socio-economic development. Only 61.4 percent of communes in the Northern Midland and Mountainous region have agricultural input suppliers, the lowest rate in the country (80.5 percent nationwide) (GSO, 2016b). Agricultural producers find it difficult to access funds for production; in 2016, only 8.8 percent had sourced credit funds compared with 19.7 percent across the country (GSO, 2016b). This stems from the low availability of credit as well as poor local knowledge on how to access credit (UNU-WIDER, 2017).



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Table 16.5 List of Future Smart Food in the mountain areas of Viet Nam

Crop	Nutrients	Altitude (m)	Topography	Rainfall	Growing period (months)
Taro (<i>Colocasia esculenta</i>)	Important source of dietary fibre and carbohydrates; high levels of vitamin A, C, E, B6, and folate, and many micro minerals	30–1 800	Flatland and sloping land, various soil conditions	Highly resistant to flooding and drought	Perennial herbaceous plants
Edible canna (<i>Canna edulis</i>)	Nutritional composition contains 4% carbohydrate, 4.8% protein, 2.8% ash, 4.35% lipid and 33.16% fibre	20–1 500	Flatland and sloping land, tolerates wet, clay-like soils, and prefers a damp growing environment	Prefer annual rainfall > 1 000 mm	6–10
Ricebean (<i>Vigna umbellata</i>)	A nutritionally rich legume, 17.26 to 21.42% protein, 3.46 to 4.03% fat, 61.09 to 64.73% carbohydrates 3.99 to 4.58% ash and 5.22 to 7.43% fibre	50–2 000	Flatland and sloping land, various soil conditions, prefers fertile loams	700–1 700 mm annually	4–6
Cowpea (<i>Vigna unguiculata</i>)	High nutritive value: crude protein in green foliage 14 to 21%, in crop residues 6 to 8%, and in grain 18 to 26%	30–1 800	Flatland and sloping land, various soil conditions, prefers well-drained soils and less adapted to alkaline soil	500–1 100 mm Cannot grow well in waterlogged conditions	3–5
Pumpkin (<i>Cucurbita moschata</i>)	High content of vitamins A, C, beta-carotene and amino acids	30–2 000	Flatland and sloping land, various soil conditions, tolerant to hot and humid conditions	600–1 800 mm annually	4–6
Banana (<i>Musa acuminata</i>)	Rich in potassium and fibre. May help prevent asthma, cancer, high blood pressure, diabetes, cardiovascular disease and digestive problems	30–1 200	Flatland to gentle sloping land	900–1 200 mm annually	9–12

16.3 Opportunities and entry points for mountain agriculture development to address Zero Hunger and poverty reduction

16.3.1 Agricultural diversification and sustainable intensification

The greatest advantage of the Northern Midland and Mountainous region is its large forest area. So the government has strongly promoted sustainable exploitation of the forest using a series of agroforestry models. Despite only a small proportion of uptake of such models, some areas have shown high economic efficiency and stability and are environmentally friendly.

Another advantage of the region is the diversity of climate, which has enabled the development of many specialty and industrial crops, such as tea, coffee and fruits. According to GSO (2018), the region produces 74 percent of the country's tea, with the most produced

in Phu Tho, Thai Nguyen, Yen Bai, Ha Giang and Son La. Coffee production occurs on approximately 21 800 ha, of which 99.9 percent is premium Arabica coffee. Fruit production is a strength of the region with 869 000 ha or 21 percent of the country's production area. Some fruits are specialized commodities with registered brand names, such as Luc Ngan litchi, Cao Phong orange and Moc Chau plum.

In recent years, sustainable production adapted to climate change has been considered for the region. In particular, smart agricultural practices have high potential for application, including shifting from the current maize and cassava monocultures to diversified farming systems. Conservation agriculture, such as mulching, minimum tillage and intercropping with legumes, are other options for protecting the environment and controlling soil erosion. Such systems will need crops adapted to and suitable for the local conditions that could also contribute to a more nutritious diet, e.g. future smart foods (Table 16.5).

16.3.2 Value-added measures and activities for agricultural products

Within the region, about 178 products are certified with a cooperative trademark and 23 have been issued geographical tracking identifications (accounting for 47 percent of the country's total); as a result, values have increased by 20 to 50 percent. This shows that opportunities exist for adding value to traditional products. The programme "One Commune, One Product" is widely used with more than 200 agricultural products recognized as regional specialties (about 12 to 15 per province).

Models of cooperative chain organization associated with processing and consumption have been beneficial for the region. Typically, enterprises and production households are linked through purchase contracts. For example, 85.1 percent of the tea area in the region has contracts between farmers and processing enterprises, which has added significant income for the farmers. There are many other agricultural products that could use this strategy.

Getting products to market in situations where transport networks are unreliable is a major barrier to agricultural development. The agricultural producers in this region are long distances from the market and must cross difficult terrain to reach them, and the added transportation costs significantly reduce net profits. Improving local agroprocessing facilities and transport systems would help resolve this issue.

16.4 Country experience

16.4.1 Sustainable farming practices

The livelihoods of people in the Northern Midland and Mountainous region depend heavily on agricultural production. Therefore, environmentally friendly farming methods are essential for enhancing economic efficiencies and adapting to climate change. Solution packages that deal with these issues depend on the target cropping system and can be grouped into three categories:

- ◆ paddy,
- ◆ rainfed sloping land, and
- ◆ integrated agricultural systems.

For paddy cultivation, potential solutions include integrated crop management, rice intensification, quick handling of straw as compost using microbial preparations, and winter crops. For sloping land cultivation, recommended practices include mulching

and minimum tillage, intercropping with legumes, mini-terraces, and planting grass as hedgerows to prevent erosion. Integrated agricultural systems include multicropping combined with short-term and long-term intercropping in trees, integration between livestock and cropping, and producing target organic or meeting Vietnamese good agriculture practices (VIETGAP) standards.

16.4.2 Policy measures and initiatives for sustainable and inclusive mountain development

Table 16.6 presents some programmes/projects that the Vietnamese government has invested in to eradicate hunger and reduce poverty in the Northern Midland and Mountainous region.

16.4.3 Case study: Purification and restoration of some specialty rice varieties

The Northern Midland and Mountainous region has many local specialty rice varieties, some of which are extremely valuable in terms of quality and adaptability to local specific growing conditions. However, most varieties have not received adequate attention for a long time, resulting in the rapid degradation of local genetic resources, which creates many problems including reduced quality and a higher risk of crop failure. Since 2005, the Northern Mountainous Agriculture and Forestry Science Institute (NOMAFSI) has collaborated with FAO, and the provincial Department of Agriculture and Rural Development (DMARD) has provided technical support to communities through many research programmes, to increase the value of these varieties, including varietal improvement, seed production and value chain development.

Those programmes comprised three main phases:

- 1 purification and production of foundation seeds through the description of original varieties, individual and line selection, and production of foundation seeds;
- 2 support for local farming communities to produce high-quality seeds, including establishing farmer groups and enhancing seed production techniques; and
- 3 assistance to farmers to certify their products before reaching the markets, which involves registering seeds with brand names and equipping farmers with marketing skills to maximize the value of their products.

Table 16.6 National programmes on hunger eradication, poverty reduction, and sustainable development in the Northern Midland and Mountainous region in Viet Nam

Programme/project	Aims	Activity/impact
National Target Program (2006–2010)	Promote production in poor households	6.2 million poor households accessed loans for production. Provided 30 000 technology transfer courses. Supplied 8 500 production guidelines to 3.7 million poor people, and free vocational training to approximately 150 000 poor labourers.
Program 134 and 135 Phase II, and Resolution 30a/2008/NQ-CP	Poverty reduction support for the 61 poorest districts	In ethnic minority areas, the average poverty rate has decreased by 4–5% each year during 2005–2008. The economic growth rate is greater than 10%. Economic structure has shifted positively and livelihoods have improved significantly.
Poverty Reduction Project in northern midland and mountainous region phase II	Improve infrastructure for accessibility, especially production, services, and developing sustainable livelihoods	Implemented in 232 communes in 27 districts of six mountainous provinces in the north.
Program 30A	Poverty reduction for those who care and protect forest land or are allocated forest and soil to plant trees	Invested VND 1,512 billion with 625,000 tonnes of rice to greater than 177 000 poor households. More than 799 000 tonnes of food have been provided to 39 800 poor households in border villages and hamlets (MARD, 2015).
Policy on loans for product development for ethnic minority households with special difficulties (2012–2015)	Loans for production	28 795 households have been granted loans. Average loan size of VND 8 million per household
Policy on directly supporting poor households in difficult areas	Loans for production	VND 559 193 billion has been allocated to implement this policy.
Scheme on socio-economic development of ethnic minority regions: Mang, La Hu, Cong, and Co Lao	Poverty reduction support	From 2011–2015, allocated capital was VND 237.67 billion, and implemented capital was VND 138.512 billion for 29 work applications.

Seven local varieties of specialty rice have been restored and purified: Huong Chiem and Tu Le sticky rice in Yen Bai; Gia Dui in Ha Giang; Sheng Cu and Khau Nam Xit in Lao Cai; Nep Tan in Dien Bien; Khau Nua Lech in Bac Kan. The seeds were then provided to the original growing areas, where they perform significantly better in terms of total production, yield, and quality. After restoration, yields have increased on average by 10 to 26 percent. In addition, using the System of Rice Intensification (SRI) has reduced the input costs per hectare by 15 percent. So the net benefits of restored varieties have increased by 20 to 25 percent. Moreover, the total annual production area of the target varieties has at least doubled. Alternatively, farmers can earn an extra 20 percent by producing seed supply rather than

solely producing grain. That seed can be used either to sell to other farmers or retained for their next cropping season.

16.5 Strategic consideration and suggestion

The Northern Midland and Mountainous region plays an important role in socio-economic development and food security. Poverty reduction in this region is the key to national sustainable development. Therefore, a variety of policies, measures and interventions have been proposed.

16.5.1 Policies

The Government of Viet Nam continues to promote the implementation of policies and projects for poverty reduction that focus on providing loans, enhancing production capacity, and increasing access to production resources and markets. In the proposed programmes and supporting policies, accelerating socio-economic development of the region in a sustainable manner is a core consideration. In addition, the government is accelerating the implementation of poverty reduction targets set by the National Assembly Resolution together with raising awareness of the people about the importance of poverty reduction. At the same time, there are policies to support production and population planning oriented towards changing local structures. Finally, specific poverty reduction models will be expanded to include combined models of poverty reduction, border security, and country defence assurance.

16.5.2 Measures and interventions

The policies on poverty reduction will be reviewed and revised regularly to ensure that they are synchronized, effective, and easy to follow. The government will take advantage of the Northern Midland and Mountainous region to enhance the impact by systematically and holistically considering agriculture, forestry, the processing industry, tourism, services and border trade. To ensure the effectiveness of the poverty reduction programmes, authorities will review and evaluate the implementation of targets, tasks, plans, projects, schemes, mechanisms and policies already promulgated. At the same time, the programmes will support the implementation of vocational training and aim to ensure food security in the long term.

16.6 Conclusion

The Northern Midland and Mountainous region of Viet Nam plays an important role in national security and environmental protection. Socio-economic development in the region promotes natural resource conservation and the sustainable development of Viet Nam.

The region has great potential for economic development, with its diversity of topography, climatic conditions, and cultures. However, agricultural production occupies a large proportion of the economic structure and therefore is highly vulnerable to poverty and hunger if the climate is not stable.

To promote socio-economic development in the region, the government has implemented many programmes and policies that support infrastructure, new rural areas, agricultural production, and accessibility to social services for the people. These programmes have helped the region to develop rapidly and sustainably.

To implement the hunger eradication programme that aims to eradicate hunger and poverty in households by 2025, the region needs further support to target market-driven agricultural production, build links between producers and enterprises, develop value chains for specialties, integrate agriculture with tourism, and create jobs. Once these targets have been achieved, the region will be able to contribute further to environmental protection, adaptation to climate change, and sustainable production.

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Part IV

CONCLUSIONS AND RECOMMENDATIONS



17 Conclusions, recommendations and the way forward for the sustainable development of mountain agriculture to enhance food security and nutrition

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These conclusions and recommendations are based on the outcomes of deliberations of the Panel of Experts at the International Workshop and Regional Expert Consultation on Mountain Agriculture Development and Food Security and Nutrition Governance, co-organized by the Asia Pacific Regional Office of United Nations Food and Agricultural Organization (FAO RAP) in Bangkok, Thailand and the University of International Relations in Beijing, China. The Workshop was held from 30 October to 1 November 2018 in Beijing, China, in collaboration with the International Crops Research Institute for the Semi-Arid Tropics (ICRISAT), the International Centre for Integrated Mountain Development (ICIMOD), Mountain Partnership and Center for International Agriculture Research of Chinese Academy of Agriculture Sciences, under Regional Initiative on Zero Hunger (RI-ZH).

17.1 Conclusions

Mountains occupy 24 percent of the terrestrial surface of the earth and are inhabited by about one billion people. The livelihoods of a large segment of mountain populations depends greatly on mountain agriculture systems. However, the challenges facing such mountain agriculture systems differ from those experienced in lowland plain agriculture. What is more, they require integrated multidisciplinary and holistic approaches to improve the livelihoods of mountain women, men and children. Urgent attention is required to reverse the declining trend in traditional mountain agriculture systems and in the loss of biodiversity, so that the world's mountain regions can contribute more effectively to global food and nutrition security. It is also essential to

improve mountain ecosystem health, which will benefit those living in upstream and downstream mountain areas.

The challenges and constraints facing the sustainable development of mountain ecosystems and agriculture in developing countries, in general, and Asia, in particular, include:

- ◆ Variable harsh environments and weather conditions including inaccessibility, fragility and seasonality of mountain areas.
- ◆ Poor infrastructure and lack of institutional services that prevail in these areas.
- ◆ Natural disasters including landslides which have tremendous impact on both livelihoods and agriculture.
- ◆ Poverty, the vast majority of people residing in mountainous areas in developing countries live below the poverty line.
- ◆ Food and nutrition insecurity, about 39 percent of mountain populations are in developing countries and are highly vulnerable to food insecurity.
- ◆ Lost economic opportunities due to poor market access and weak relevant institutional services.
- ◆ Policy marginalization and lack of involvement of mountain people in policy development and decision-making relevant to the development of mountain areas.
- ◆ Degradation of natural resources due to their overexploitation as a result of poverty.

- ◆ Climate change implications, where drought is becoming a common phenomenon.
- ◆ Water scarcity as a result of drought and excessive use of water resources for agricultural purposes.
- ◆ Soil and fertility erosion.
- ◆ Loss of biodiversity as a result of overgrazing, soil erosion and landslides.
- ◆ Land degradation and desertification.
- ◆ Migration, particularly of men, to downstream areas and large cities seeking better livelihoods.
- ◆ Low mountain agriculture productivity and production as a result of the above constraints.
- ◆ Overall mountain ecosystem degradation.

Special attention and concentrated solutions targeting mountainous and hilly areas in developing countries, in general, and Asia, in particular, are needed to address poverty, improve livelihoods, enhance food security and nutrition, and halt or reverse the degradation of mountain ecosystems. It was apparent from the country presentations during the International Workshop that the sustainable development of mountain ecosystems and agriculture is critical to exploit their full potential and thereby improve livelihoods and enhance food security and nutrition of the mountain populations. Sustainable development of mountain ecosystems and agriculture requires long-term investments in holistic and integrated approaches involving policy, socioeconomic and institutional aspects, natural resource management, and crop and livestock improvement. It is important to holistically address economic, social, environmental, cultural and political issues by considering the contrasting situations of different farming systems to ensure the sustainable development of mountain ecosystems and agriculture that will benefit both the mountain and lowland populations.

17.2 Recommendations

To address the various challenges facing mountain ecosystems and agriculture, the International Workshop and Regional Expert Consultation event offered a set of policy and programming recommendations for the sustainable development of mountain agriculture to enhance food security and nutrition governance in Asia and contribute to the Zero Hunger initiative.

The Workshop and Regional Expert Consultation event offered various approaches/modalities for the way forward for sustainable mountain agriculture

development to enhance food security, nutrition governance, and improve livelihoods in the region. This will contribute to the eradication of poverty and hunger, which are global and regional priorities as specified in SDG 1 and SDG 2. It is, therefore, an essential component of the FAO Regional Initiative on Zero Hunger Challenge, based on country needs, regional priorities, and all Strategic Programmes. It is important to fulfill the strong desire of countries for knowledge sharing and lessons learned at the regional level to promote sustainable mountain agriculture in practice for enhancing food security and nutrition in mountain areas to contribute to Zero Hunger and poverty reduction.

The Workshop and the Expert Consultations concluded their deliberations with the following recommendations that need to be implemented at the national and regional level to contribute to the sustainable development of mountain ecosystems and agriculture (Figure 17.1).

17.2.1 Policy, socioeconomic and institutional support

The Workshop participants emphasized the importance of developing an enabling policy environment by considering the socioeconomic conditions of mountain people, the challenges facing both mountain ecosystems and agriculture, and the institutional support required for its sustainable development. The following are specific recommendations for consideration and implementation by countries to develop an enabling policy environment and institutional support:

- ◆ Develop and implement policies, strategies and programmes to address challenges, including the socioeconomic and ecosystem-based challenges facing different farming systems and zones of sustainable mountain agriculture development.
- ◆ Increase attention to risk management and develop policies for prevention, mitigation and relief to cope with natural disasters.
- ◆ Strengthen existing and establish new national institutions to provide public services, including extension and microcredit to support the development of sustainable mountain agriculture.
- ◆ Involve representatives of mountain communities in decision-making, policy development and implementation as well as in initiatives that support the development of sustainable mountain agriculture

- ◆ Increase the enabling environment for land tenure to consolidate land holdings to ensure investment in long-term appropriate land management. Attention needs to be paid to developing farmers' cooperatives to transfer subsistence agriculture to commercial agriculture for agricultural productivity and income.
- ◆ Develop infrastructure in mountain areas to support agricultural development and improve livelihoods of mountain communities.
- ◆ Increase the levels of investment and financial support for the sustainable development of mountain agriculture at national, regional and international levels
- ◆ Increase the resilience of mountain farmers and small agro-industrial enterprises by linking them with markets and providing subsidies to add value to mountain products, especially Future Smart Food (FSF) as well as other non-food products, to diversify the incomes of mountain communities, particularly the incomes of women.
- ◆ Establish a mountain agriculture fund and funding mechanism for both replenishment and support of agricultural services, activities, and value-added products in mountainous areas.
- ◆ Conserve water resources and develop rain water harvesting through both macro- and micro – water catchments to conserve water in soil and use irrigation to mitigate and cope with long periods of drought.
- ◆ Promote environmentally friendly and ecological practices including bio-fertilizers and bio-pesticides to reduce pollution.
- ◆ Halt and even reverse the reduction of biodiversity and prevent excessive grazing of livestock as well as emphasize the sustainable use of biodiversity.
- ◆ Promote the agroforestry landscape model by growing forage shrubs that reduce the pressure of grazing on rangelands and natural pastures.

17.2.3 Crop and livestock improvement and integration

The improvement of crops and livestock production is a precondition for enhancing food production and, ultimately, food security and nutrition. The following recommendations need to be considered by policymakers, researchers, extension workers, farmers and producers involved in mountain ecosystems and agriculture:

17.2.2 Natural resource management

The Workshop participants emphasized the importance of halting and reversing the degradation and unsustainable use of natural resources including water, soil and biodiversity in mountain ecosystems. The following recommendations need to be considered and implemented in this regard:

- ◆ Promote the conservation and sustainable use of natural resources of regional and global importance which are also important to mountainous areas: natural resources, water, biodiversity, soil, natural pastures and forests.
- ◆ Ensure the adaptation and mitigation of measures to cope with natural hazards as a result of climate change and their pressure on natural resources.
- ◆ Prevent land degradation and build up soil fertility through:
 - ◆ Using different types of terracing for efficient farming. Planting along contour lines for better water catchment and the reduction of erosion
 - ◆ Diversify cropping systems (including legumes), use mixed and intercropping production systems
 - ◆ Promote conservation agriculture, zero tillage and crop rotation.
- ◆ Ensure the development of integrated livestock/crop/rangeland farming systems for effective utilization of natural resources.
- ◆ Develop improved crop varieties adapted to the diverse mountain environments and climate change, including NUS that have great potential as commercial FSF.
- ◆ Promote the cultivation of traditional crop varieties such as FSF and highlight the crucial role of mountain people as custodians of these varieties.
- ◆ Establish livestock community breeding with herders and pastoralists whereby unproductive animals are culled and productive animals are retained to improve livestock populations and herds.
- ◆ Diversify agriculture production and encourage the production of high-value crops, including fruit trees, vegetable and ornamentals as well as value-added products in both crop and livestock production to improve nutrition, income and livelihoods.
- ◆ Promote protected agriculture (mulch, row covers, shade structures, greenhouses, etc.) to intensify the production of high-value crops and increase water use and production efficiencies per unit area in mountain agriculture.

17.2.4 Research, technology transfer and capacity Development

The Workshop participants emphasized the critical importance of making improved technologies and technical know-how available to mountain farmers and producers to bridge the gap between current low productivity and its full potential. This is feasible through the strengthening of specialized well-targeted research in mountain agriculture and the extension of efficient technology transfer to enhance the capacity development of human resources and institutions. The following recommendations address this area:

- ◆ Increase the long-term investment of research programmes in national research institutions and universities to enhance capacity and address the specific challenges facing the sustainable development of mountain agriculture.
- ◆ Develop and modernize extension institutions that specialize in transfer technologies and technical know-how to mountain farmers and agriculture producers through efficient approaches and make use of the tools and facilities already developed through the revolution in information technology, such audiovisual aids (e.g. TV programmes) and mobile phones.
- ◆ Develop and support capacity building (mountain agriculture curriculum and web-based technology in relevant universities) and extension targeting different stakeholders, including farmers' programmes to promote the sustainable development of mountain agriculture.
- ◆ Establish farmer and pastoralist field schools and women's empowerment programmes to transfer/exchange technologies and skills to address the challenges facing these important stakeholders.
- ◆ Develop and implement communication programmes and audiovisual aids to promote advanced technologies and knowledge on the development of sustainable mountain agriculture.
- ◆ Make use of International Mountain Day on 11 December to organize events and workshops to promote the sustainable development of mountain agriculture.

17.2.5 Regional and international cooperation

The challenges and problems facing mountain ecosystems and agriculture are often complex, transboundary and difficult to resolve by a single country or institution. A good example is the challenges

and problems of transboundary mountain ecosystems and river basins that originate from mountain areas. Therefore, intercountry regional cooperation should be established in areas of common interest, and the following recommendations need to be implemented at the regional or sub-regional level:

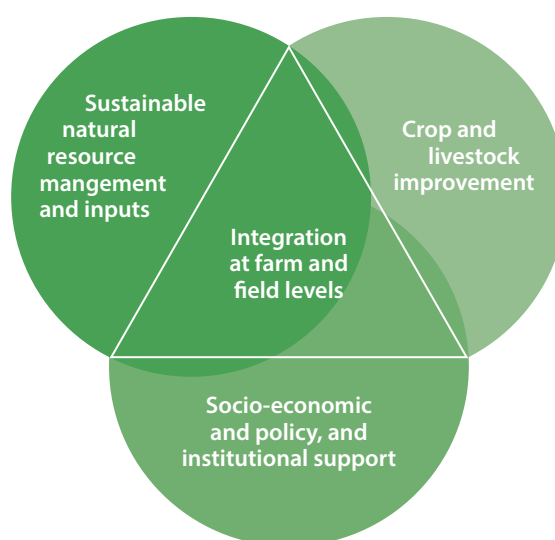
- ◆ Strengthen and develop south–south cooperation at the regional level in countries where mountain ecosystems and agriculture constitute a substantial part of the country's agro-ecologies. This involves national research and development in institutions and universities interested in mountain ecosystems and agriculture.
- ◆ Strengthen international cooperation with the United Nations, regional and international cooperation, particularly with FAO, Mountain Partnership, ICIMOD, CGIAR and other relevant institutions
- ◆ Strengthen Mountain Partnership, considering it is the only United Nations voluntary alliance of partners dedicated to improve the lives of mountain people and protect mountain environments in the world as well as increase public–private sector attention, commitment, engagement and investment in the development of sustainable mountain agriculture.

17.3 Implications for food security and nutrition governance

The sustainable development of mountain ecosystems and agriculture is critical for improving food security and livelihoods in vulnerable mountain communities and protecting mountain natural resources, namely water, soil and biodiversity. These natural resources are also important for food security and improving the livelihoods of people living in the surrounding lowlands. Considering the implications to both upstream and downstream populations, at least one billion people are affected by the sustainable development of mountain ecosystems and agriculture.

Mountain people make use of the variation in climates at different altitudes, with different exposures to sunlight from season to season (FAO, 2011). Traditional land-use systems for agricultural production make use of climate variations through sophisticated techniques. Mountain areas have diverse agro-ecologies and as a result, mountain agriculture has different production systems for farming and natural pastures, including 1) pastoral, 2) agro-pastoral systems (both are important to livestock production), 3) rainfed and 4) irrigated production systems and 5) forestry and agroforestry. Both rainfed

Figure 17.1 The three major pillars for the development of sustainable mountain agriculture and their integration at farm and farmer levels to achieve synergy in productivity and production



and irrigated production systems are important for field crops such as rice, wheat and corn, and horticultural crops including fruit trees and vegetables. The production of livestock, field and horticultural crops are the basis for food security and nutrition.

Mountain areas have many NUS that may be important Future Smart Foods if special attention is given to their nutritional value and adaptation to harsh environments and variable climatic conditions. It is important to assess the nutritional value and adaptation to prevailing NUS in the traditional mountain communities. Furthermore, nutritional value assessments will shed light on their potential to become important commercial crops at national, regional and global levels. A good example is quinoa, which originated in the traditional communities of the Andes Mountains in Latin America that has become a globally important food because of its high nutritional value.

17.4 The way forward

The policy, technical, and regional and international cooperation recommendations presented above should be adopted and implemented by national authorities and specialized regional, international and United Nations organizations (where FAO can play an important coordinating role). The implementation of these recommendations will contribute greatly to healthy mountain ecosystems and utilize the full potential of mountain agriculture. This will not only contribute to global food and nutrition security but also ensure the continued services and resources that contribute 70 percent of freshwater resources and various sources

of renewable energy to the world community. Both water and energy are critical to the water–energy–food nexus essential for food and nutritional security, environmental sustainability and poverty reduction.

The sustainable development of mountain agriculture requires the leadership from the government to place mountain agriculture in the centre of national and sub-national policies related to Zero Hunger and poverty reduction, and long-term investment in a holistic and integrated approach involving policy, socioeconomic, institutional aspects, natural resource management, and crop and livestock improvement. The investment should be followed by integration among all these factors in farmers' fields to achieve synergy as a result of the integration of these three important themes 1) sustainable natural resource management and inputs; 2) crop and livestock improvement, and 3) socioeconomic, enabling policies, and institutional support.

Negligence of mountain areas, where about one billion people reside, has contributed greatly to global poverty, food insecurity and malnutrition. It is essential that governments develop specialized institutions at the national level to address the multilateral challenges facing the sustainable development of mountain ecosystems and agriculture. These institutions need to implement the policy, technical and regional cooperation recommendations to improve livelihoods, reduce poverty and enhance food and nutritional security.

References

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Original partners of FAO's Mountain Agriculture initiative



"It is no secret that mountain people endure incredibly difficult environments and face the highest levels of food and nutrition insecurity. However, based on the strong cultural assets of long standing adaptation and resilience and a unique capacity to take advantage of diversity, sustainable mountain agriculture development offers considerable opportunities to achieve the four dimensions of food security. Promoting mountain specialty products (e.g. Future Smart Foods) through identification, production, post-harvest handling and processing, marketing and consumption, should be considered an effective entry point for mountain agriculture to contribute to Zero Hunger and to Sustainable Development."

Dr Patrick Caron, Chairperson of High Level Panel of Experts (HLPE) of the UN Committee on world Food Security (CFS)

"Mountain agriculture – imperative for livelihoods, nutrition, as well as its role at supporting agricultural diversity – is now at a crucial juncture, given pressures from climate change, disasters and outmigration. Yet, research and support systems pay inadequate attention to mountain farmers and their agricultural systems, which are distinctly different from those found on the plains. The FAO Mountain Agriculture initiative in Asia and Pacific is therefore, importantly positioned and well-timed to draw the necessary urgent attention in support of a prosperous and sustainable transformation of mountain agricultural systems, vital for the world to achieve food and nutrition security and to meet the United Nation's SDGs."

Dr David Molden, Director General of the International Centre for Integrated Mountain Development (ICIMOD)

"This FAO publication provides strong and convincing evidence that governments and society as a whole need to pay more attention to the potential of mountain agriculture for achieving food and nutrition security, to improve livelihoods and economic opportunities and to ensure sustainable ecosystems which collectively will lead to SDGs."

Dr Kraisd Tontisirin, Senior Advisor of the Institute of Nutrition, Mahidol University and Former Director, Food and Nutrition Division at FAO, Rome, Italy

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