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

Xuan Li, Senior Policy Officer and Delivery Manager of Regional Initiative on Zero Hunger, FAO RAP; Kadambot H.M. Siddique, FAO Special Ambassador for International Year of Pulses and Hackett Professor of Agriculture Chair and Director, The University of Western Australia; Mahmoud El Solh, Vice Chair of the High Level Panel of Experts for Food Security and Nutrition of the CFS of UN; and Thomas Hofer, Senior Forestry Officer and Group Leader of Natural Resources Management Group, FAO RAP

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 disproportionally 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

<table>
<thead>
<tr>
<th>Subregion</th>
<th>Number of vulnerable mountain people (000)</th>
<th>Percentage change 2000–2012 (%)</th>
<th>Distribution of vulnerable mountain people (%)</th>
<th>Vulnerable mountain people out of total mountain people (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Central Asia</td>
<td>2 023</td>
<td>3 136</td>
<td>55</td>
<td>1.3</td>
</tr>
<tr>
<td>Eastern Asia</td>
<td>84 449</td>
<td>93 595</td>
<td>11</td>
<td>55</td>
</tr>
<tr>
<td>Southeastern Asia</td>
<td>18 257</td>
<td>21 532</td>
<td>18</td>
<td>12</td>
</tr>
<tr>
<td>Southern Asia</td>
<td>35 181</td>
<td>54 150</td>
<td>54</td>
<td>23</td>
</tr>
<tr>
<td>Western Asia</td>
<td>12 655</td>
<td>20 364</td>
<td>61</td>
<td>8</td>
</tr>
<tr>
<td>Total</td>
<td>152 564</td>
<td>192 778</td>
<td>26</td>
<td>100</td>
</tr>
</tbody>
</table>

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.

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. 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.
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.
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 specialty 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 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 (Hussain et al., 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 relay 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 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 the 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, colocasia, 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 Yunnanyang, 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 agriclimate 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 major 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
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 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

Evidence-based policies to create an enabling environment for mountain agriculture development and food security and nutrition governance
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 the Institutional Framework on 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
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 made 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 agriclimates 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.

References


FAO. 2018a. *State of Food Security and Nutrition in the World 2018*. S.l., Food and Agriculture Organization of the United Nations; Centre for Development and Environment of the University of Bern; Centre for Development Research, University of Natural Resources and Life Sciences, Vienna.


