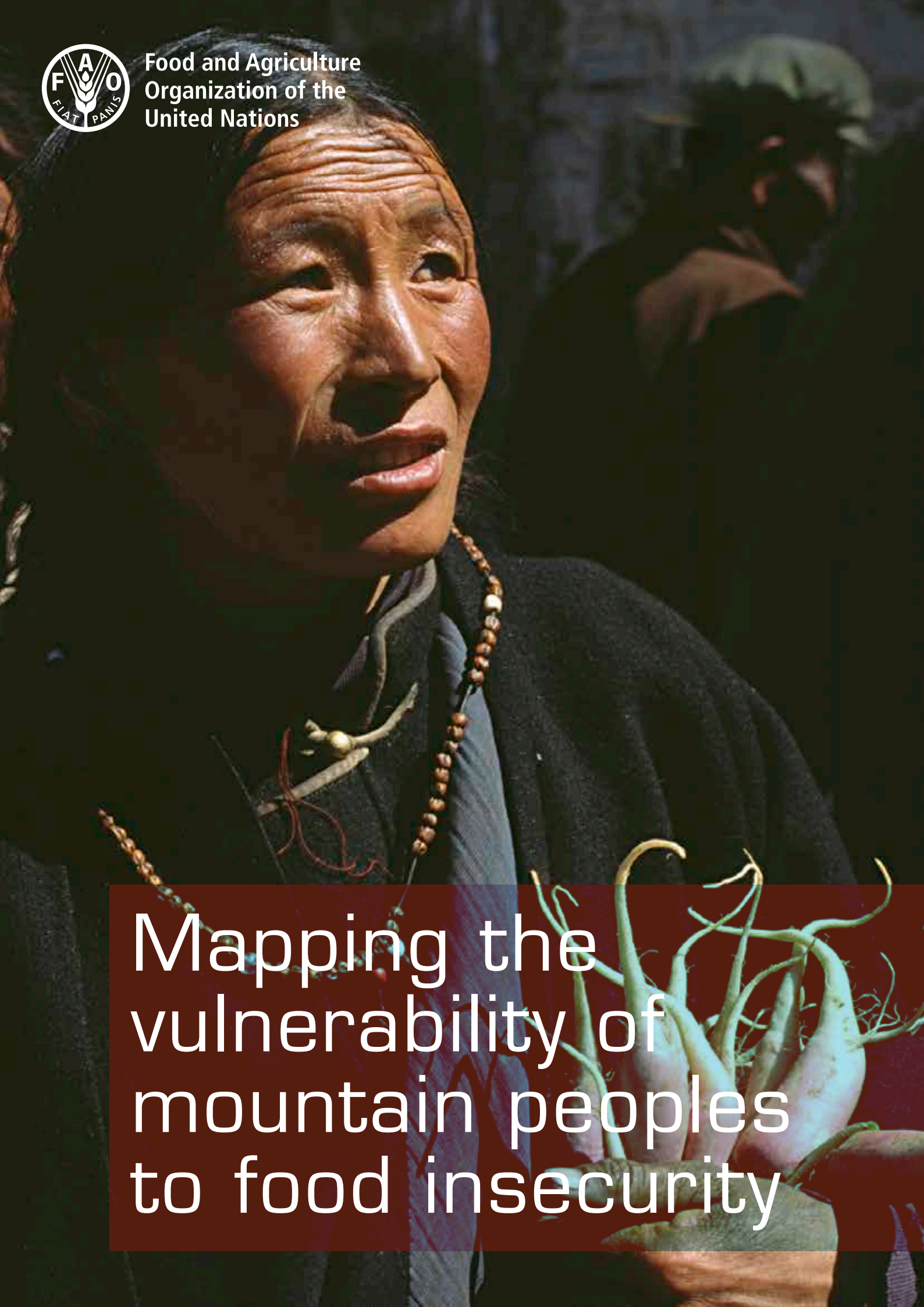

Food and Agriculture Organization of the United Nations

Mapping the vulnerability of mountain peoples to food insecurity

Cover photo: Woman holding indigenous crops in the old town of Lhasa, People's Republic of China (©Jack Ives)

Mapping the vulnerability of mountain peoples to food insecurity

In collaboration with
the Mountain Partnership Secretariat

FOOD AND AGRICULTURE ORGANIZATION OF THE UNITED NATIONS
Rome, 2015

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Foreword

This study, conducted by FAO and the Mountain Partnership Secretariat, draws attention to an alarming fact: in 2012, 39 percent of the mountain population in developing countries was considered vulnerable to food insecurity, which is an increase of 30% compared to the conditions of mountain peoples in the year 2000. The situation is even worse if we consider only rural mountain peoples.

The living conditions of mountain peoples have deteriorated and their vulnerability to hunger has increased. Harsh climates and the difficult, often inaccessible terrain, combined with political and social marginality certainly contribute to making mountain peoples particularly vulnerable to food shortages.

In mountain areas, where family farming and smallholder agriculture, forestry and animal husbandry are the prevailing farming systems, it is essential to create a supportive, enabling environment in which mountain peoples have access to training, information, credit and healthcare, and benefit from reliable governance systems and infrastructure.

FAO has been promoting sustainable mountain development since founding the Mountain Partnership, jointly with the governments of Italy and Switzerland and the United Nations Environment Programme, in 2002.

The Mountain Partnership Secretariat, which is hosted at FAO, works with the 263 members to improve the livelihoods of mountain peoples through advocacy, capacity development and joint action on the ground.

The data revealed in this study gives voice to the plight of mountain peoples. This study provides a clear message to policy-makers on the importance of including sustainable mountain development in their agendas. As we now endeavour to reach the Sustainable Development Goals, the international community and resource partners are hereby called upon to invest in mountain areas and reinforce the efforts of FAO and the Mountain Partnership Secretariat.

José Graziano da Silva

José Graziano da Silva,
Director-General, Food and Agriculture Organization of the United Nations

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Acronyms

ADER	Average dietary energy requirement
CDE	Centre for Development and Environment (University of Bern)
CVI	Composite vulnerability indicator
DEC	Dietary energy consumption
FAO	Food and Agriculture Organization of the United Nations
GIS	Global information system
GLC	Global land cover
GRUMP	Global Rural-Urban Mapping Project
Kcal	Kilocalorie
IFPRI	International Food Policy Research Institute
IHS3	Third Integrated Household Survey
INEC	Ecuadorian National Statistics Institute
IPCC	Intergovernmental Panel on Climate Change
Kcal	Kilocalories
LER	Local elevation range
MP	Mountain Partnership
MPS	Mountain Partnership Secretariat
SOFI	State of Food Insecurity
SPAM	Spatial Production Allocation Model
UN	United Nations
UNU	United Nations University
UNEP	United Nations Environment Programme
VIP	Ventilated improved pit
WCMC	World Conservation Monitoring Center (UNEP)
WHO	World Health Organization

Executive summary

Mountains cover 22 percent of the world's land surface and are home to some 915 million people, representing 13 percent of global population. Mountains also provide between 60 and 80 percent of the earth's fresh water. Yet, in spite of this global relevance, there is a dearth of data and information on the status of mountains and mountain peoples. In 2003, the Food and Agriculture Organization of the United Nations (FAO) published "Towards a GIS-based analysis of mountain environments and populations", a study that estimated mountain peoples' vulnerability to food insecurity. The study, undertaken as a follow-up to the 2002 UN International Year of Mountains, has become a cornerstone of development efforts. It is used and quoted, for as a reference, requesting more investments, specific policies and global attention toward mountains.

A current analysis of hunger in mountainous areas

Now, more than ten year later, this report is an update on the 2003 study, providing a new understanding of trends in mountain areas and more targeted information on the current situation.

This study, produced by FAO and the Mountain Partnership Secretariat (MPS), first presents an updated geographic and demographic picture of the world's mountain areas and population, based on data gathered from the most recent datasets. The core of the study is the analysis of mountain vulnerability to food insecurity, conducted on the basis of a new methodology – the FAO 2015 Mountain Vulnerability Model – which was developed after thorough consultations between FAO and external experts on mountain development, nutrition, statistics, livestock and GIS techniques.

The study defines vulnerability to food insecurity as the probability of a person or household falling or staying below a minimum food security threshold within a certain timeframe. Mountains are classified according to the United Nations Environment Programme-World Conservation Monitoring Center (UNEP-WCMC) classification, which rates six classes based on elevation and slope, ranging from Class 1 with an elevation of greater than 4 500 m to Class 6 with an elevation of 300 to 1 000 m. Countries are grouped according to the UN Statistics Division M.49 standard, which divides the world into five macrogeographic regions – Africa, Americas, Asia, Europe and Oceania – and distinguishes between developing and developed areas.

According to the new analysis results, 39 percent of mountain population (urban and rural combined) in developing countries were considered vulnerable to food insecurity in 2012. This is a 30 percent increase in the number of vulnerable mountain people in the 12 years since 2000, while the mountain population itself has increased just 16 percent. The numbers are even more shocking if only considering mountain people who live in rural areas. While the global average of food insecure people in developing countries is one in eight, almost half of those who live in developing countries' rural mountain areas are vulnerable to hunger, and face poverty and malnutrition.

The global mountain population increased from 789 to 915 million people between 2000 and 2012, with 90 percent living in developing countries. The growth was not equal across the regions, *e.g.* Africa, and Latin America and the Caribbean had increases of 38 and 22 percent, respectively, from 2000 to

2012, while the mountain population of Asia grew by only 8 percent in the same period. Population also increased in all of the elevation classes except the highest, which saw a sharp decrease. Middle elevation classes showed the most significant population growth, particularly in South America where many cities, including national capitals, are located in mountain areas.

The analysis of the population data found that, in 2012, on average, 30 percent of the mountain population lived in urban areas, increasing from 26 percent in 2000. Half of the mountain inhabitants of developed countries, but only a quarter of those in developing countries, live in urban areas.

The FAO 2015 Mountain Vulnerability Model

The FAO 2015 Mountain Vulnerability Model was formulated under the guidance of FAO experts, the Mountain Partnership Secretariat (MPS) and Mountain Partnership (MP) members. It provides the most accurate possible estimate of the vulnerability to food insecurity in mountain areas, based on the best technologies and data available. The model was applied only to developing countries, on the assumption that peoples in developed countries are not food insecure and that factors other than agriculture are relevant to their livelihoods. It is also worth noting that the mountain population of developed countries has only increased by 12 percent since 2000. For rural people, the model defines vulnerability based on caloric and protein requirement per day, while for urban populations it uses the World Bank urban poverty indicator.

The model provides an estimate of the caloric availability in rural mountain regions, considering the production rate of agricultural areas as an average of the yields of six main mountain crops (beans, cassava, maize, potatoes, rice and wheat) expressed in calories. It then adds information on food quality by estimating the availability of proteins from beef meat, cow milk, sheep meat, sheep milk, goat meat, goat milk, pig meat, chicken meat and eggs.

In practice, the FAO 2015 Model is based on a more refined set of indicators than those used in the previous study but it has limitations. It does not capture productive activities other than agriculture and animal husbandry. That means that income from activities such as forestry, tourism and trade, as well as remittances and salaries that comprise or complement the livelihoods of mountain peoples, were not included.

Afghan Internally Displaced Persons (©UN Photo/Eskinder Debebe)

Household surveys: another tool to measure hunger

Case studies were undertaken in Ecuador and Malawi in an attempt to test the validity of the model, and results were aligned overall. The studies were based on real data from household surveys to verify the results obtained from the model, and to illustrate what could be achieved if georeferenced household data were available and analysed for all countries.

The mountain areas of the two countries have different socio-economic conditions. Ecuador is an upper middle-income country where mountain people live mostly in urban areas. Malawi is a low-income food insecure country where most mountain people live in rural areas. The studies used a newly developed composite vulnerability indicator that accounts for both food security and social protection measures.

Household survey data included food consumption patterns and living conditions as well as factors such as water quality, sanitation facilities and road networks. The data collected enabled estimates of vulnerability to food insecurity in the countries by both elevation classes and ethnic groups.

As the case studies illustrated, having this wide range of information allows for holistic assessment of vulnerability to food security and for precise localization of vulnerability hot spots which, in turn, can facilitate and support design of policy interventions.

Results and conclusions of the study

In comparing data from 2000 to the new information gathered in 2012, the study found that the 30 percent increase in the number of mountain people considered vulnerable to food insecurity meant that the number of vulnerable people in developing countries had increased to nearly 329 million, compared with 253 million in 2000. The study also identified changes in the number of vulnerable mountain people in all developing regions and subregions of the world.

Current regional maps based on data from the study show large areas already abandoned by vulnerable people who faced situations so dramatic that they were compelled to leave. Not only did their migration increase the population pressure on the already poor areas where they ended up settling, their leaving also resulted in losses in the areas they left behind – in terms of provision of ecosystem services and preservation of cultural and agrobiological diversity.

Overall, it should be noted that although the data indicates that one of every three mountain people in developing countries is vulnerable to food insecurity, when only rural areas are considered, this figure increases to one out of every two mountain people. Based on the FAO State of Food Insecurity in the World 2015 report, the average number of people suffering from chronic hunger in developing countries is one out of eight.

Having this level of data gives voice to, and quantifiable understanding of, the plight of mountain peoples. It sends a clear message to policy-makers on the importance of including mountain development in their agendas – development that can alleviate the harsh living conditions of mountain communities and slow outmigration from mountain areas.

Infographics of the results

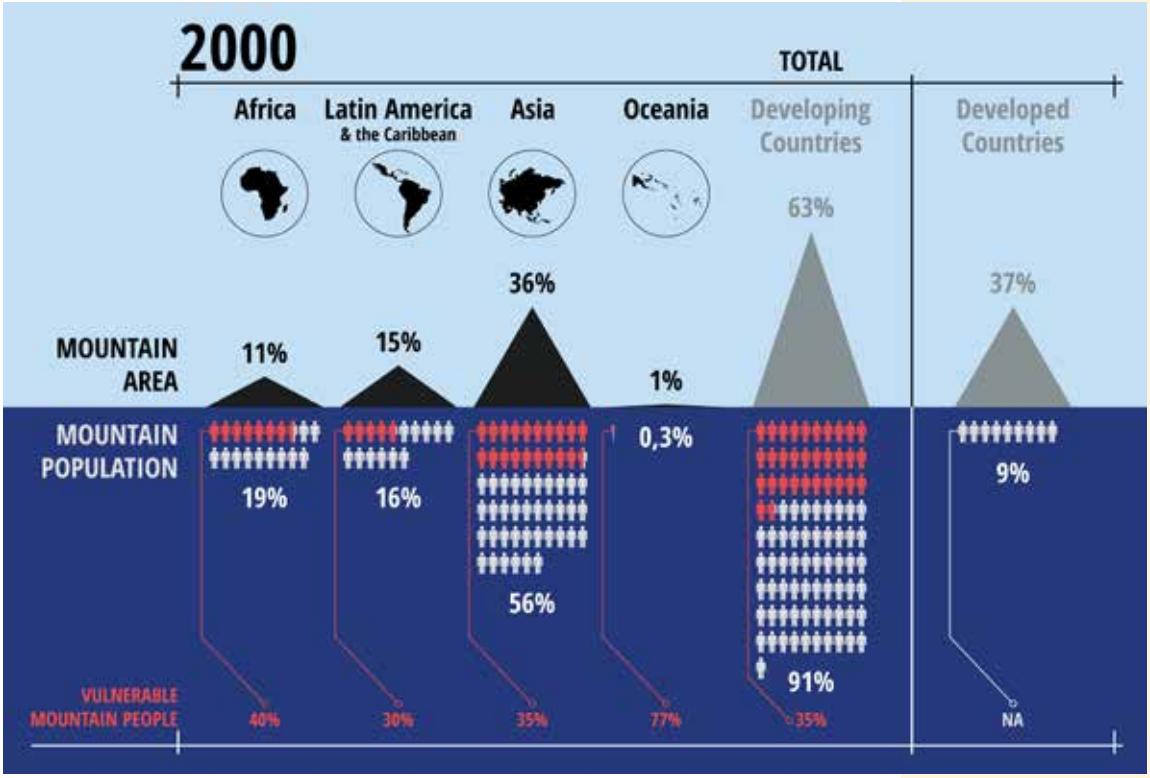


Figure 1. Mountain areas, population and vulnerability to food insecurity in 2000

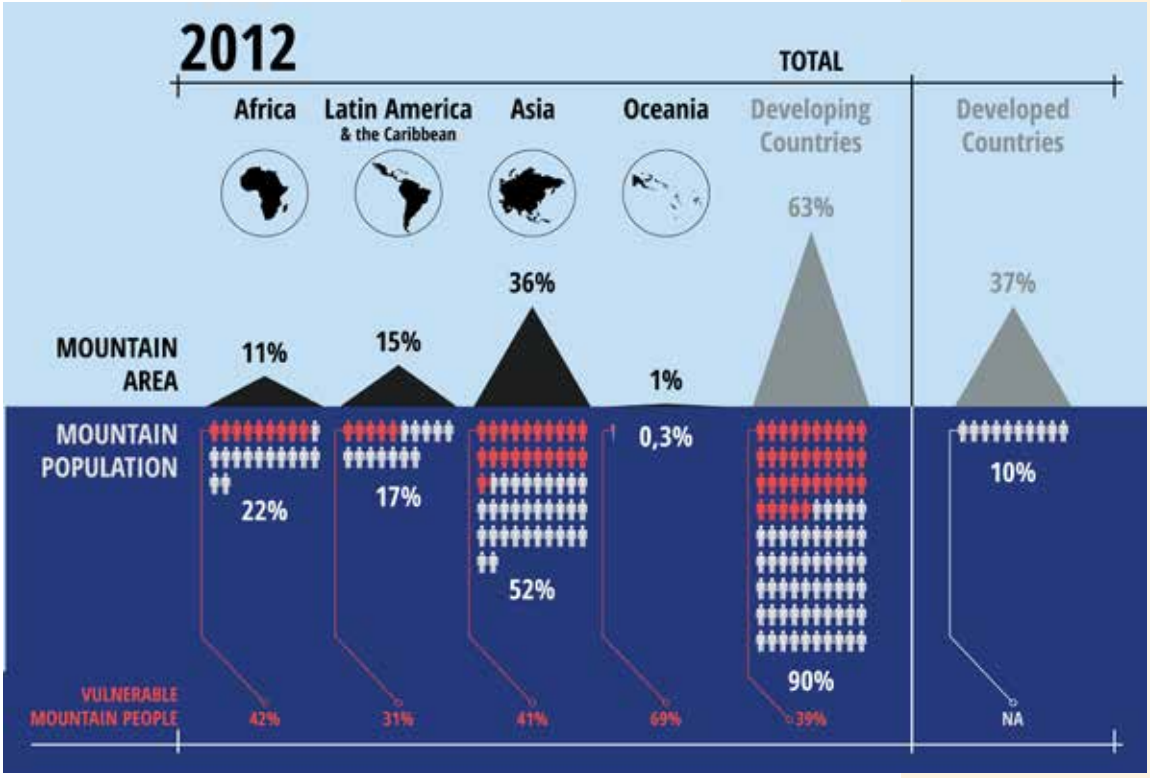


Figure 2. Mountain areas, population and vulnerability to food insecurity in 2012

Introduction

People walk to the Kiroka market, Tanzania, with their goods (@FAO/Daniel Hayduk)

Introduction

Radhia Abdul Kulunge's onions and tomatoes at the Kiroka market, Tanzania (@FAO/Daniel Hayduk)

People living in mountain areas are particularly vulnerable to food insecurity. Slopes with steep and differing elevations often make the soil shallow, poor in micronutrients, limited and difficult to cultivateand unsuitable for mass agricultural production. Distance from roads, poor infrastructure and marginalization render access to markets more difficult. Further, the occurrence and magnitude of extreme climatic events are traditionally higher in mountains than in lowlands, a situation that is increasing due to climate change.

In 2002, in observing the International Year of Mountains, the Food and Agriculture Organization of the United Nations (FAO) dedicated a special section of its annual *State of Food Insecurity* (SOFI) report to mountain areas. In 2003, the FAO report *Towards a GIS-based analysis of mountain environments and populations* enriched this information. The report both investigated the conditions underlying poverty and hunger in mountain environments and informed the international community of the extent of vulnerability in mountains so that, in turn, effective policies and programmatic activities could be formulated to answer the needs and challenges faced by mountain people. Until now, the data presented in that report – based on research carried out more than ten years ago – remained the only such data available at global scale.

Recognizing the priority need for updating the data, FAO, the MPS and MP members determined to reassess the vulnerability of mountain peoples to food insecurity, and analyse the main trends that have occurred at global, regional and national levels since the 2003 study. All the maps, tables and figures in this study have been produced using a new methodology developed by FAO and its partners – which is explained in detail in section 2.

Vulnerability in the food security context

FAO defines food security as the condition that "exists when all people, at all times, have physical and economic access to sufficient, safe and nutritious food that meets their dietary needs and food preferences for an active and healthy life" (World Food Summit, 1996). The definition is therefore based on four main dimensions: physical availability of food; economic and physical access to food; adequate food utilization (good general hygiene and sanitation, water quality, health care practices, and food safety and quality so that the body can make the most of various nutrients in the food); and stability of the other three dimensions over time.

When incorporating vulnerability into the analysis of food security, the concepts of poverty, food insecurity and vulnerability are often used interchangeably, frequently leading to misunderstandings. However, most misunderstandings can be cleared by viewing the concepts with a time perspective – poverty and food insecurity generally refer to people's conditions at the present time, while vulnerability embeds a forward-looking perspective that is used to predict if the well-being of individuals and households is likely to change in future.

Vulnerability, in the food security context, can be defined as the probability of a person or household falling or staying below a minimum food security threshold within a certain timeframe. In these terms, while vulnerability refers to the ex-ante probability of falling or remaining below a specific threshold, food insecurity is actually being below the threshold. Vulnerability has often been associated with the idea of "living on the edge" to symbolize the precarious state faced by people living under such a condition. A unique approach to measuring vulnerability to food insecurity does not exist, because such a measurement must be related to a specific dimension of food security or a nutritional outcome.

Vulnerability within mountain farming systems

In virtually all mountain areas across the world, crop-based farming systems are important components of local livelihoods. These include, *e.g.* the maize-bean system in the upland areas of central Mexico and Central America, the perennial-crop-based system of the Ethiopian and eastern African highlands, and the

Mountainous agriculture, China (©GEF)

rice-wheat (highland-mixed) system found across the entire Himalayan range. At higher elevations and in dry mountain environments, animal husbandry fulfills a prominent role in food and income generation.

However, for millions of mountain people, hunger and the threat of hunger are nothing new. Harsh climates and the difficult, often inaccessible terrain, combined with political and social marginality make mountain people vulnerable to food shortages. Hunger and micronutrient deficiencies contribute to the significantly higher infant mortality rates in mountain regions, where maternal mortality is also higher than in the lowlands. It is important to understand that hunger and malnutrition are not merely symptoms of poverty in mountain communities – they contribute to perpetuate poverty.

This publication presents a geographic and demographic picture of the world's mountain areas. It then traces the vulnerability trends that have impacted the dynamics of mountain populations and assesses their exposure to food insecurity through a methodology specifically developed for this study.

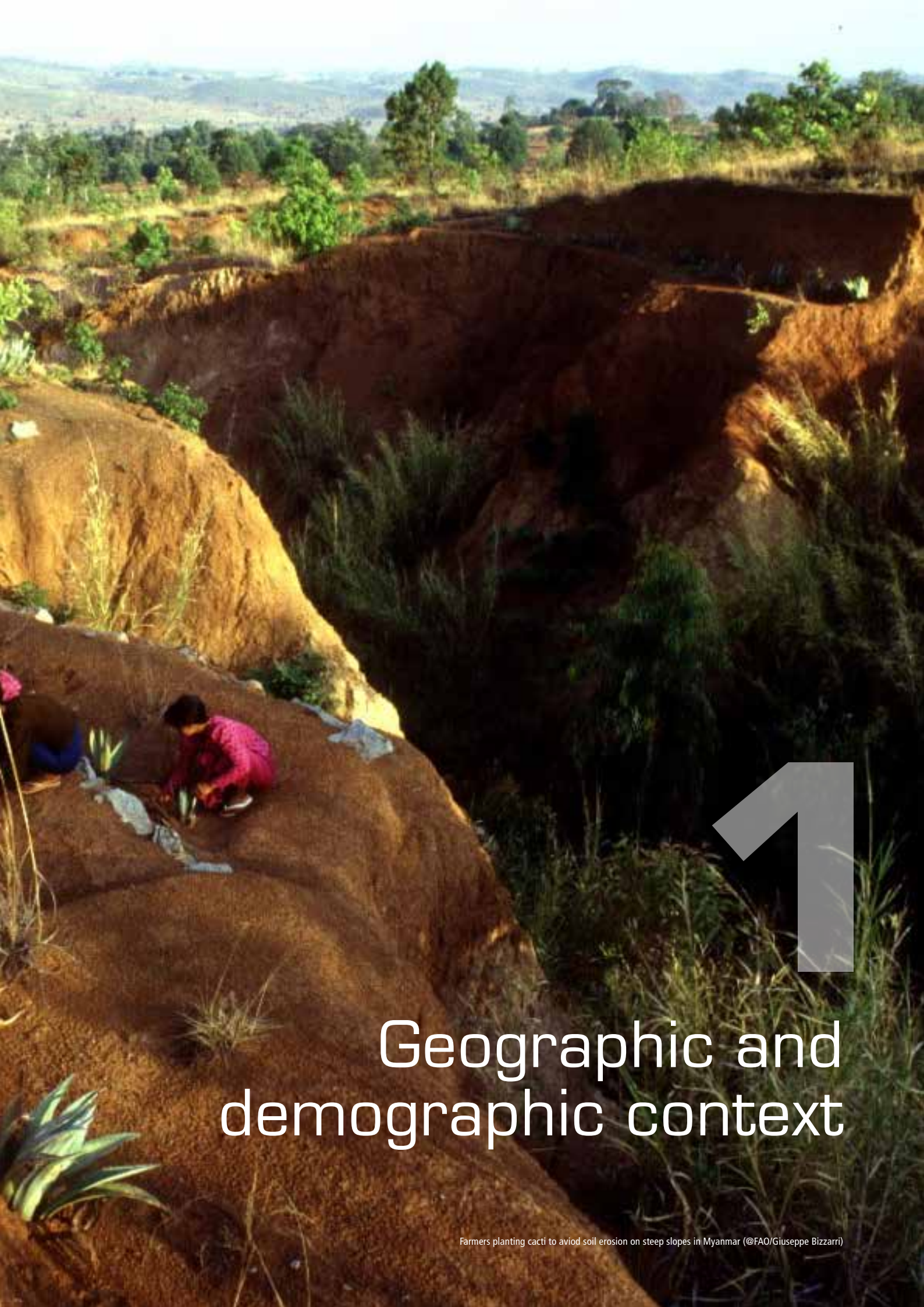
This analysis covers the years 2000 to 2012, a 12-year period chosen to ensure continuity. The previous FAO study on mountain vulnerability conducted in 2003 was based on data from 2000, and 2012 data were the latest available when this analysis was initiated. Thus, this report builds from an analysis based on 2000 data that covered all the mountain areas of the world, but adds a new global approach that combines GIS and statistics techniques. As one of the main goals of this study was to identify the main trends for mountain vulnerability, the data in the 2003 report were completely recalculated in order to base the analysis on fully harmonized, comparable and consistent numbers. The great amount of new data that has been collected will be made available on-line on the Mountain Partnership website to support further studies, analyses and discussions.

Halaba, Ethiopia is one of the smallest and youngest neighbourhoods of Hawassa and a fast growing economy (@FAO/Eddy Patrick Donkeng)

The final section of the publication presents an alternative and complementary approach based on an analysis of household surveys which used a composite index developed specifically for this study. Because of the lack of data for many countries, this methodology is currently only suitable for national and subnational analysis and can be implemented only if information on the position of the households is available. Still, its potential to improve the quality and accuracy of the information is tremendous.

Investing in targeted data gathering and adding mountain-specific items to the existing national household surveys would enable a wider application of the composite index and result in a significant improvement in understanding the food security situations of mountains dwellers.

Workers sift coffee beans in Timor-Leste (©UN Photo/Martine Perret)



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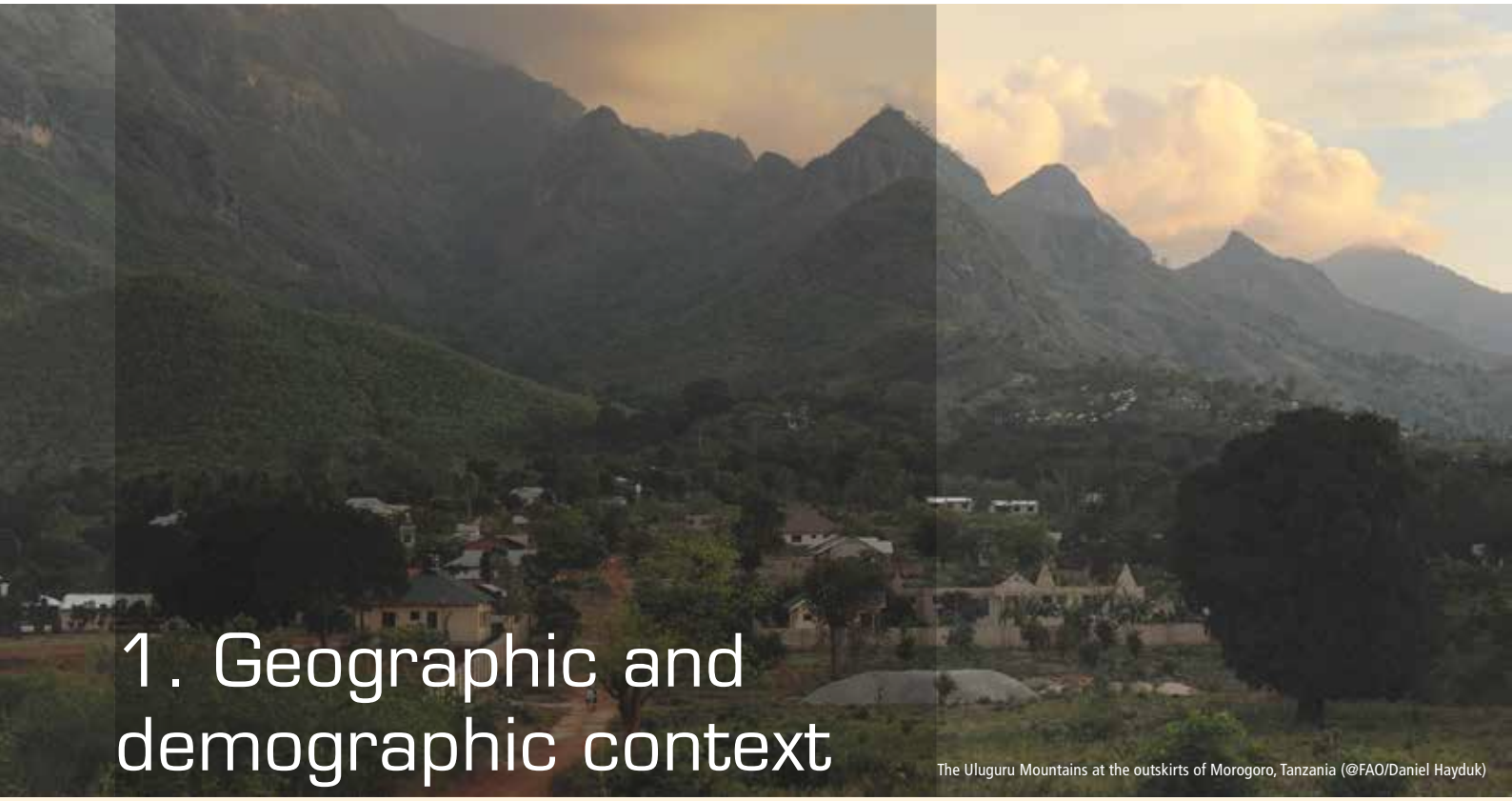
Geographic and demographic context

Farmers planting cacti to aviod soil erosion on steep slopes in Myanmar (@FAO/Giuseppe Bizzarri)



1. Geographic and demographic context

The Uluguru Mountains at the outskirts of Morogoro, Tanzania (@FAO/Daniel Hayduk)

Mountain areas of the world

The definition of mountain is not univocal. Individual countries and institutions adopt their own criteria for distinguishing mountains from hills and plains, which impacts efforts to gather global data. In fact, this lack of univocal definitions can lead to significant differences in results if, for example, latitudinal, climatic, topographic and cultural specificities cannot be reflected in a definition with global relevance.

For this publication, mountains are defined according to a topographic criterion that combines altitude above sea level, steepness of slope and local elevation range (LER). This classification was developed in 2000 by the United Nations Environment Programme – World Conservation Monitoring Center (UNEP-WCMC) in order to represent the environmental gradients that are key components of mountain environments.

The classification indicates six elevation classes of mountains according to the following scheme:

- Class 1: elevation ≥ 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 ≥ 2°
- Class 5: elevation 1 000–1 500 m and slope ≥ 5° or LER > 300 m
- Class 6: elevation 300–1 000 m and LER > 300 m

A seventh class, identified in 2002, includes isolated inner basins and plateaus measuring less than 25 km^2 that are surrounded by mountains but do not themselves meet the criteria of the other classes. However, many research projects, including this publication, have not taken this new class into account because it represents flat areas of relatively low elevations that would present fewer constraints in terms of productivity and mobility. Lowlands can be referred to as Class 0.

Grouping scheme

Countries have been grouped according to the United Nations (UN) Statistics Division "M.49" standard. M.49 is a geoscheme that divides the world into macrogeographical regions and subregions, and allows for the generation of selected economic groupings. M.49 identifies five macrogeographical regions: Africa, Americas (Northern America and Latin America & the Caribbean), Asia, Europe and Oceania.

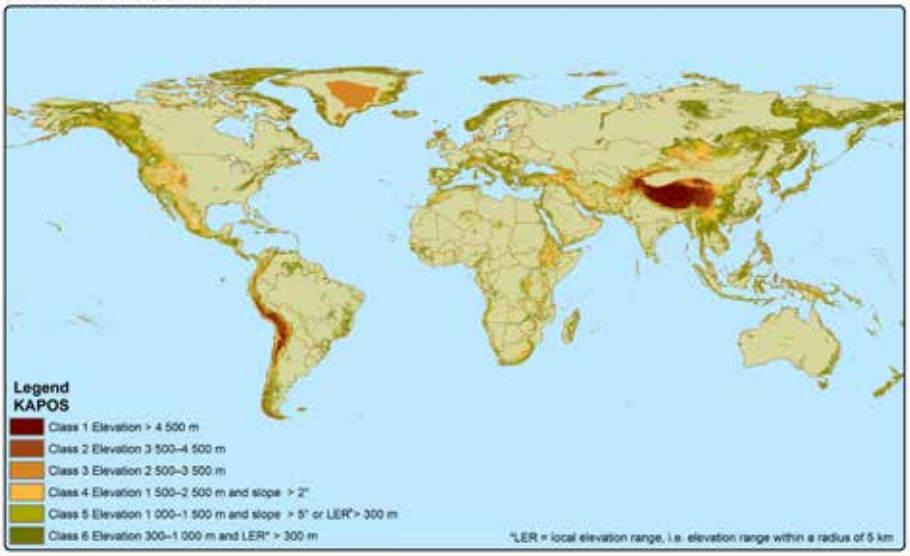
This framework also allows for the allocation of countries to developing and developed regions. The designations "developed" and "developing" are intended solely for statistical convenience and do not necessarily express a judgment about the stage reached by a particular country or area in the development process. While there is no established convention for this designation in the United Nations system, in common practice it considers Japan in Asia, Canada and the United States in Northern America, Australia and New Zealand in Oceania, and Europe as developed regions, and all the other areas are considered developing regions.

In view of the focus on developing countries of this study, developed countries are considered as a whole, while data for developing countries are presented at the regional and subregional level.

Mountains of the world

Mountains cover 32 million km^2, which is 22 percent of the world's land surface (Map 1).

This is a slight increase of the area classified as mountain in comparison to the data presented in 2003, which reported 29 million km^2 of land covered by mountains. The change in the mountain areas calculation is due to the improvements in the resolution and accuracy of remote sensing models since 2000. Information and communication technologies and remote sensing developments have opened new ways and strategies for quantitative analysis and scientific research in



Map 1. Mountains of the world. Elaborated by CDE using the UNEP-WCMC classification of mountains (Kapos *et al.*,2000)

mountain environments: sensors observe the landscape more frequently and with higher resolution, and newly elaborated methodologies provide better access to information related to patterns, status and trends of mountain environments.

Mountain ranges are not homogeneously distributed around the globe (Figure 3, Table 1). Asia alone hosts more than one-third of the world's mountains, including Mount Everest in the Himalayan chain which, at 8 848 m, is the world's highest peak. Thirty-seven percent of mountains are located in developed countries – 18 percent of them in Europe, 17 percent in Northern America, 1 percent in Australia and New Zealand, and 1 percent in Japan. Fifteen percent of the world's mountain massifs cross the Latin America and the Caribbean region. This includes the Andean chain which, at more than 7 000 km, is the world's longest range. African mountains, which account for 11 percent of the total, have especially important roles in the continent's life. They are often the granaries of their countries due to higher rainfall and high quality agricultural land, and also serve as water towers for the vast surrounding drylands. Finally, the remaining 1 percent of mountains are found on the Melanesian, Micronesian and Polynesian subregions of Oceania. Almost half of the world's highlands peak at less than 1 000 m (Class 6) and, overall, only 10 percent of mountains are higher than 3 500 m (Classes 1 and 2) (Figure 4).

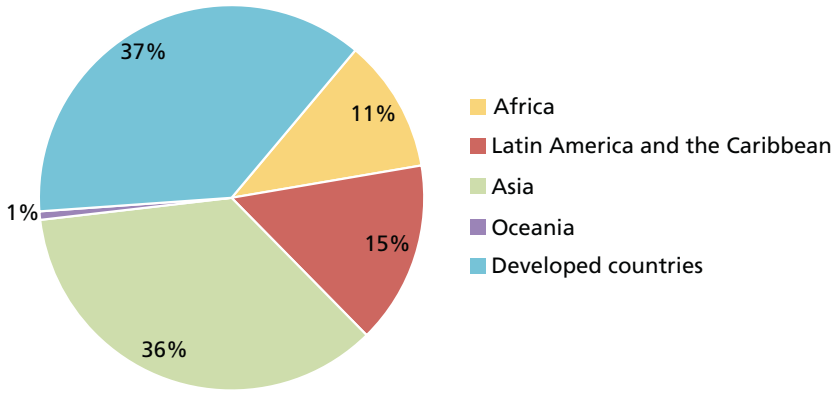


Figure 3. Distribution of mountain areas by region

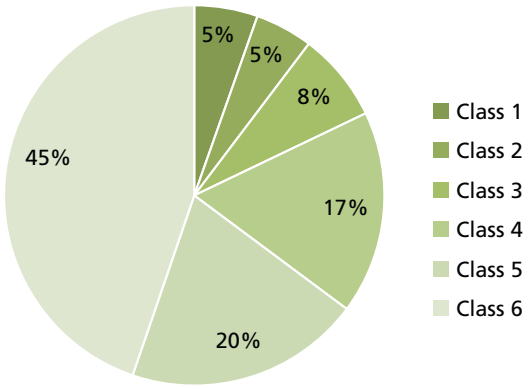


Figure 4. Distribution of mountain areas by elevation class

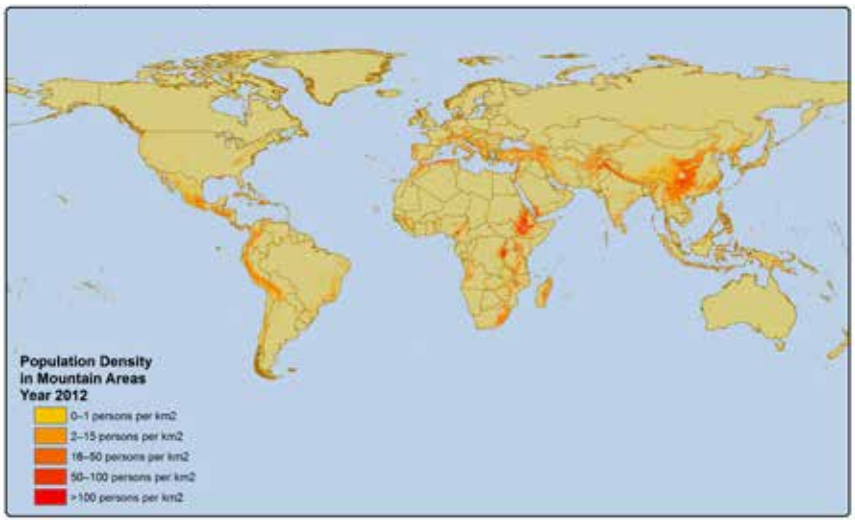
Region/ subregion	Mountain area (000 km2)							
	Class 1	Class 2	Class 3	Class 4	Class 5	Class 6	Total	Global distribution of mountains (%)
Developing countries	**1 751**	**1 577**	**1 630**	**3 881**	**3 959**	**7 562**	**20 360**	**63**
Africa	0.085	5	100	727	1 089	1 713	3 633	11
Eastern Africa	0.080	5	79	434	527	622	1 666	5
Middle Africa	0.005	0.099	5	110	183	363	661	2
Northern Africa	-	0.154	6	64	173	344	587	2
Southern Africa	-	-	10	116	189	209	524	2
Western Africa	-	-	0.003	3	17	175	195	1
Latin America & the Caribbean	156	594	439	881	839	2 060	4 970	15
Caribbean	-	-	0.055	3	6	41	49	0.2
Central America	0.039	1	68	411	276	433	1 189	4
South America	156	593	371	468	558	1 586	3 731	12
Asia	1 595	978	1 074	2 220	1 991	3 670	11 528	36
Central Asia	28	92	110	119	89	129	566	2
Eastern Asia	1 420	735	625	1 026	789	1 331	5 926	18
South-Eastern Asia	0.411	6	24	119	320	1 137	1 606	5
Southern Asia	147	144	273	659	458	650	2 331	7
Western Asia	0.014	0.607	41	298	335	423	1 099	3
Oceania	-	0.680	17	52	40	119	229	1
Melanesia	-	0.680	17	52	40	116	227	0.7
Micronesia	-	-	-	-	-	0.147	0.147	0.0005
Polynesia	-	-	-	0.064	0.267	2	2	0.01
Developed countries	**0.226**	**14**	**832**	**1 728**	**2 552**	**6 952**	**12 078**	**37**
World	**1 752**	**1 591**	**2 462**	**5 609**	**6 511**	**14 514**	**32 438**	**100**

Table 1. Mountain areas by region and mountain elevation class

Women in mountains (©Flickr/Attraction Voyages Pérou & Bolivie)

A portrait of mountain populations: key facts and figures

In 2012, 915 million people lived in mountain areas (Map 2), representing 13 percent of the global population (Figure 5). Of them, 90 percent or 835 million lived in developing countries. Data have been collected through GIS technology for the years 2000 and 2012, in order to assess the changes that occurred during the years after the FAO 2003 study was released.



Map 2. Population density in mountain areas of the world in 2012

The mountain population's share of global population has remained stable while, in absolute terms, there has been a 16 percent increase in mountain population, which is in line with global population growth.

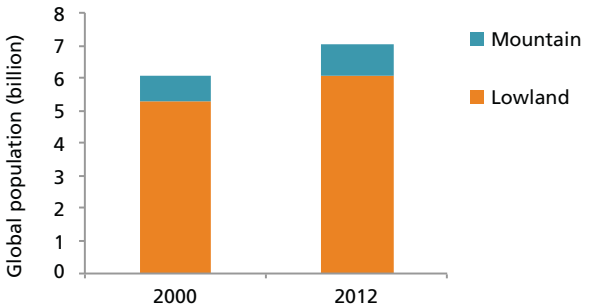


Figure 5. Global mountain and lowland population in 2000 and 2012

Global mountain population increased from 789 to 915 million people between 2000 and 2012. However, it evolved differently according to the different geographic regions and subregions of the world (Table 2; Figure 6A, 6B). In developing countries, 718 million people lived in mountain areas in 2000, increasing to more than 835 million in 2012. Africa and Latin America and the Caribbean saw great increases of 38 and 22 percent, respectively, in their overall mountain populations from 2000 to 2012. Although the mountain population of Asia grew by only 8 percent in this same period, about half (52 percent) of world mountain people still live in the Asian region, while 22 percent live in Africa, 17

Fighting Continues in DRC (©UN Photo/A Burridge)

percent in Latin America and the Caribbean, 9 percent in developed countries and 0.3 percent in the developing countries of Oceania. The low number of mountain people living in Oceania is due to the fact that Australia and New Zealand are grouped with developed countries and thus the region includes only the smaller islands and archipelagos.

A 90-year old man in Tunisia (©UN Photo/Kate Schafer)

Region	Number of mountain people ('000)		Percentage change 2000-2012 (%)	Distribution of mountain population among regions (%)	
	2000	2012		2000	2012
Africa	147 352	202 858	**38**	19.0	22.0
Latin America & the Caribbean	128 905	156 711	**22**	16.0	17.0
Asia	438 884	472 399	**8**	56.0	52.0
Oceania	2 561	3 145	**23**	0.3	0.3
Developed countries	71 694	80 359	**12**	9.0	9.0
World	**789 396**	**915 472**	**16**	**100**	**100**

Table 2. Mountain population by region in 2000 and 2012

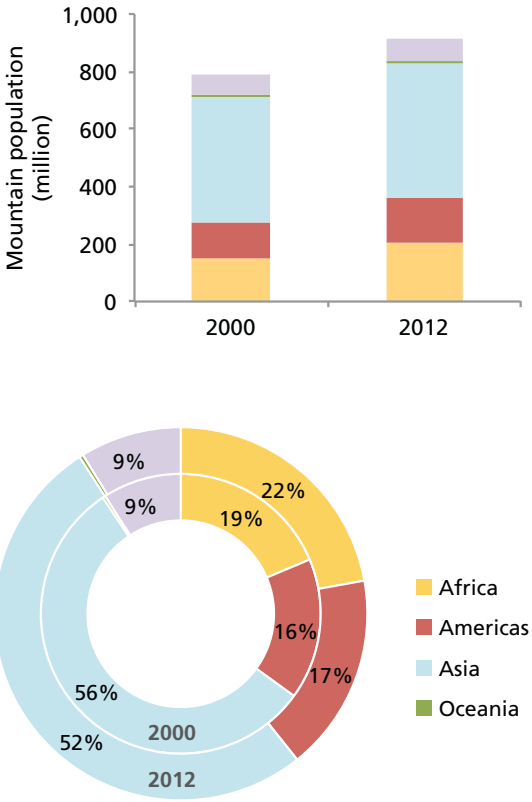


Figure 6A and 6B. Mountain population by region in 2000 and 2012

When comparing population figures with the km^2 covered by highlands in each region, it emerges that mountain population density is not homogeneous. European mountain areas, for example, account for about a 18 percent of global mountain land cover, while their inhabitants are only 7 percent of the total mountain population. The opposite is true in Asia and Africa, which are characterized by 36 percent and 11 percent of mountain land coverage respectively, but the Asian mountains alone are home to half of the global mountain population, and Africa follows with 22 percent.

The population trend analysed at the subregional level (Figure 7) shows worldwide mountain population growth, with the exception of Eastern Asia, Micronesia and Polynesia which decreased 9, 94, 51 percent respectively. Nevertheless, Eastern Asia remains the most populated mountain area in spite of the decrease. On the other hand, Northern and Southern Africa, Caribbean and Southern Asia present interesting cases, with the percentage of their mountain population increasing more strongly than the total subregional one (*i.e.* including lowlands, too). In Northern Africa the mountain population grew 34 percent while the total population grew by only 23 percent; in Southern Africa the corresponding growth rates were 32 and 17 percent; in the Caribbean 35 and 19 percent; and in Southern Asia 38 and 19 percent.

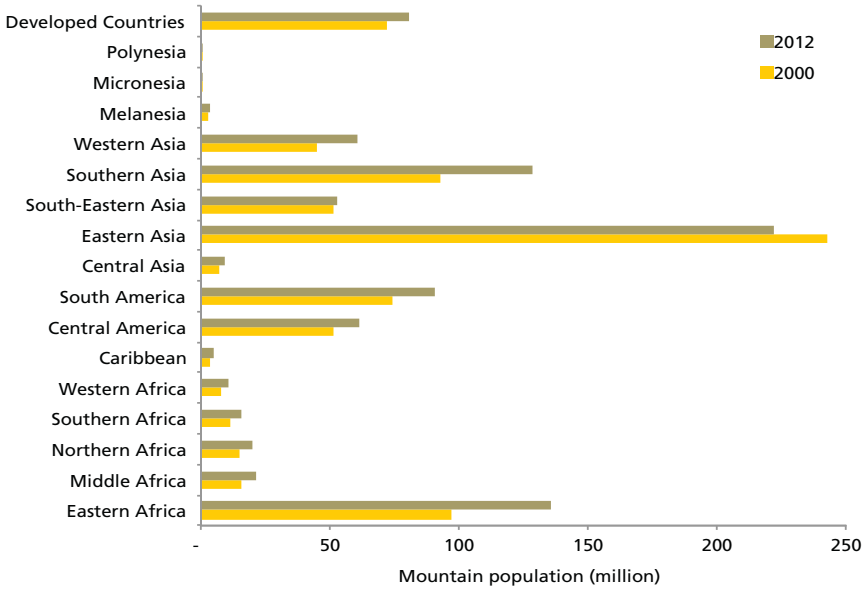


Figure 7. Mountain population in 2000 and 2012 by subregion

Community partners of Caritamaya, Puno, Peru planting and composting potato in rehabilitated sukaqollos (©A. Canahua)

The changes were also analysed with respect to the six elevation classes, in order to understand whether the change in mountain population was uniform at all altitudes or not (Table 3; Figure 8A, 8B). Overall, population growth affected all the elevation classes except the highest. The number of people living above 4 500 m (Class 1) decreased by one-third in 12 years. The majority of mountain population still lives between 300 and 1 000 m (Class 6) and has increased by 10 percent. A considerable increase observed between 1 000 and 3 500 m (Classes 3, 4 and 5) can be mainly ascribed to developing countries, where middle elevation classes showed the most significant population growth. This was particularly evident in South America, which has many cities including capitals located in these mountains classes.

The share of people belonging to each elevation class has remained rather stable over the last decade (Table 3; Figure 8B). In fact, now as then, about 70 percent of mountain people live below 1 500 m (Class 5 and 6), while only 9 percent live above 2 500 m and 2 percent above 3 500 m.

Elevation	Number of mountain people ('000)		Percentage change 2000-2012 (%)	Distribution of mountain population within elevation classes (%)	
	2000	2012		2000	2012
Class 1	3 753	2 482	**-34**	0.5	0.3
Class 2	12 669	13 524	**7**	1.6	1.5
Class 3	48 671	60 101	**23**	6	7
Class 4	154 948	194 722	**26**	20	21
Class 5	157 471	192 431	**22**	20	21
Class 6	411 884	452 212	**10**	52	49
Total	**789 396**	**915 472**	**16**	**100**	**100**

Table 3. Mountain population by elevation class in 2000 and 2012

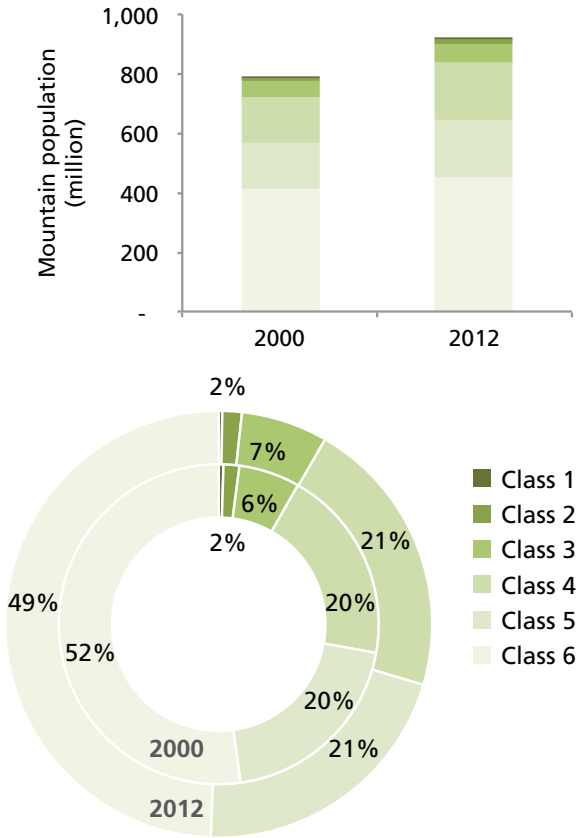


Figure 8A and 8B. Mountain population in 2000 and 2012 by elevation class

The distribution of the population by mountain elevation class differs significantly from one region to another and also within the subregions of the same area (Tables 4 and 5). In 2012, 10 percent of mountain people in South America lived above 3 500 m, the share even reaches 35 percent if the analysis is extended to include those living between 2500 and 3500. This is a very peculiar case, as no other subregion in Latin America and the Caribbean nor elsewhere presents a similar situation. History and geography offer insight, as the region was the cradle of ancient civilizations such as the Incas and is also rich in mineral resources, which led to early urbanization and higher population densities. Eastern Africa also presents a unique case, with about 50 percent of mountain dwellers living at altitudes ranging from 1 500 to 2 500 m, so that there is more population living in this elevation than in the two lower elevation classes added together. African mountains are often areas of high agricultural potential due to favorable climate and soils, and this is reflected in population distribution.

In developed countries a depopulation trend has affected all elevations above 2 500 m where mountain settlements are increasingly abandoned by people migrating to the lowlands, most likely in quest of better employment conditions.

A mountain woman and her child in Luang Probang, Laos (©UN Photo/Robaton)

Region/subregion	2000 Mountain Population ('000 people)						
	Class 1	Class 2	Class 3	Class 4	Class 5	Class 6	Total
Developing countries	**3 753**	**12 663**	**48 426**	**152 291**	**151 351**	**349 219**	**717 702**
Africa	0.927	247	12 365	57 007	36 408	41 325	147 352
Eastern Africa	0.760	244	11 745	47 684	24 340	13 267	97 281
Middle Africa	0.167	2	331	4 556	4 738	5 744	15 371
Northern Africa	-	0.693	46	987	3 182	10 836	15 052
Southern Africa	-	-	243	3 732	3 449	4 241	11 665
Western Africa	-	-	-	47	698	7 237	7 982
Latin America & the Caribbean	1 052	7 638	22 099	24 127	19 322	54 666	128 905
Caribbean	-	-	0.444	56	230	3 137	3 424
Central America	1	65	6 148	16 650	10 654	18 060	51 578
South America	1 051	7 573	15 951	7 421	8 438	33 469	73 903
Asia	2 699	4 775	13 726	70 011	95 238	252 434	438 884
Central Asia	4	124	273	905	1 795	4 254	7 353
Eastern Asia	1 575	3 202	7 123	41 653	51 069	138 361	242 984
South-Eastern Asia	0.505	19	75	1 607	7 584	41 802	51 088
Southern Asia	1 120	1 429	4 774	17 936	22 656	44 937	92 851
Western Asia	-	0.229	1 481	7 910	12 135	23 081	44 608
Oceania	-	3	235	1 146	382	793	2 561
Melanesia	-	3	235	1 146	382	772	2 538
Micronesia	-	-	-	-	-	3	3
Polynesia	-	-	-	0.333	0.907	18	19
Developed countries	**-**	**6**	**246**	**2 658**	**6 120**	**62 665**	**71 694**
World	**3 753**	**12 669**	**48 671**	**154 948**	**157 471**	**411 884**	**789 396**

Table 4. Global overview of mountain population by region/subregion and elevation class in 2000

Region/subregion	2012 Mountain Population ('000 people)						
	Class 1	Class 2	Class 3	Class 4	Class 5	Class 6	Total
Developing countries	**2 482**	**13 524**	**59 796**	**190 623**	**186 239**	**381 004**	**835 114**
Africa	0.641	354	16 268	76 770	49 904	58 118	202 858
Eastern Africa	0.521	349	16 017	65 944	34 786	18 356	135 451
Middle Africa	0.120	5	208	6 425	6 267	8 294	21 198
Northern Africa	-	0.741	36	923	3 953	15 194	20 107
Southern Africa	-	-	7	3 389	4 020	6 559	15 418
Western Africa	-	-	-	90	878	9 716	10 684
Latin America & the Caribbean	757	8 496	28 452	29 816	24 498	64 690	156 711
Caribbean	-	-	0.300	92	402	4 125	4 621
Central America	0.040	23	6 370	20 281	13 461	21 303	61 438
South America	757	8 473	22 082	9 443	10 635	39 262	90 651
Asia	1 724	4 672	14 852	82 165	111 356	257 631	472 399
Central Asia	11	32	171	1 081	2 518	5 501	9 315
Eastern Asia	1 526	3 650	6 987	40 197	48 125	121 375	221 860
South-Eastern Asia	0.557	219	311	1 802	8 841	41 228	52 402
Southern Asia	187	770	5 951	27 659	35 103	58 439	128 109
Western Asia	-	0.026	1 432	11 424	16 769	31 088	60 714
Oceania		2	224	1 873	481	565	3 145
Melanesia	-	2	224	1 873	481	555	3 135
Micronesia	-	-	-	-	-	0.190	0.190
Polynesia	-	-	-	0.013	0.014	9	9
Developed countries		**0.587**	**199**	**2 795**	**6 157**	**71 207**	**80 359**
World	**2 482**	**13 524**	**59 996**	**193 418**	**192 396**	**452 210**	**915 472**

Table 5. Global overview of mountain population by region/subregion and elevation class in 2012

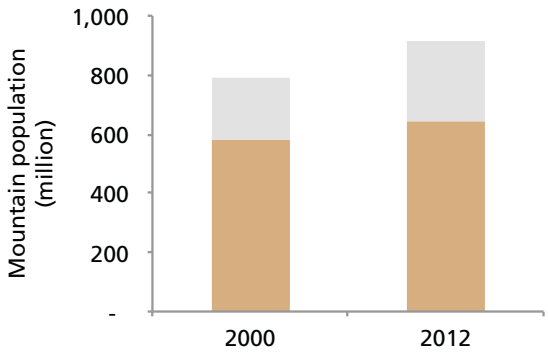
Nepalese children (©Alma Karsymbek)

Urban versus rural population

In 2012, urban mountain population reached 273 million, which accounted for 30 percent of total mountain population. This represented an increase of 33 percent compared with 12 years before, although the majority of people (642 million) still lived in rural settlements (Table 6; Figure 9A, 9B).

Settlement	Number of mountain people ('000)		Percentage change 2000–2012 (%)	Share (%)	
	2000	2012		2000	2012
Urban	205 287	273 111	33	26	30
Rural	584 109	642 361	10	74	70
Total	**789 396**	**915 472**	**16**	**100**	**100**

Table 6. World mountain population living in urban and rural areas in 2000 and 2012



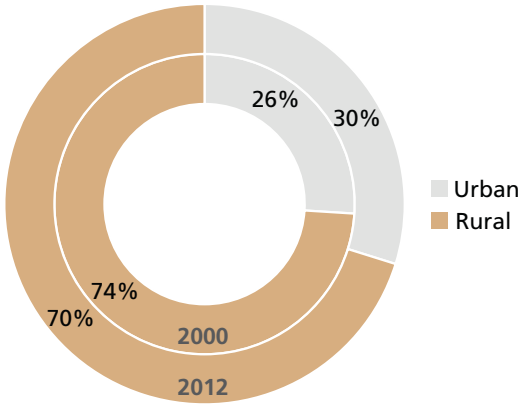


Figure 9A and 9B. World mountain population living in urban and rural areas in 2000 and 2012

Noteworthy differences appear when comparing developing and developed countries, subregions and elevation classes (Table 7). Overall, in developed countries, half of the mountain inhabitants are settled into urban centres while, in developing countries, only a quarter live in a town or a city. Compared with the year 2000, urban population is expanding in all mountain areas, especially in developing countries. This growth is mainly driven by South America, where it is common to have major cities located at high altitudes.

The pattern of mountain urbanization is overall aligned with the global urbanization trend, despite the fact that mountain topography makes it harder to establish large urban communities.

A participant at the first World Conference on Indigenous Peoples (©UN Photo/Loey Felipe)

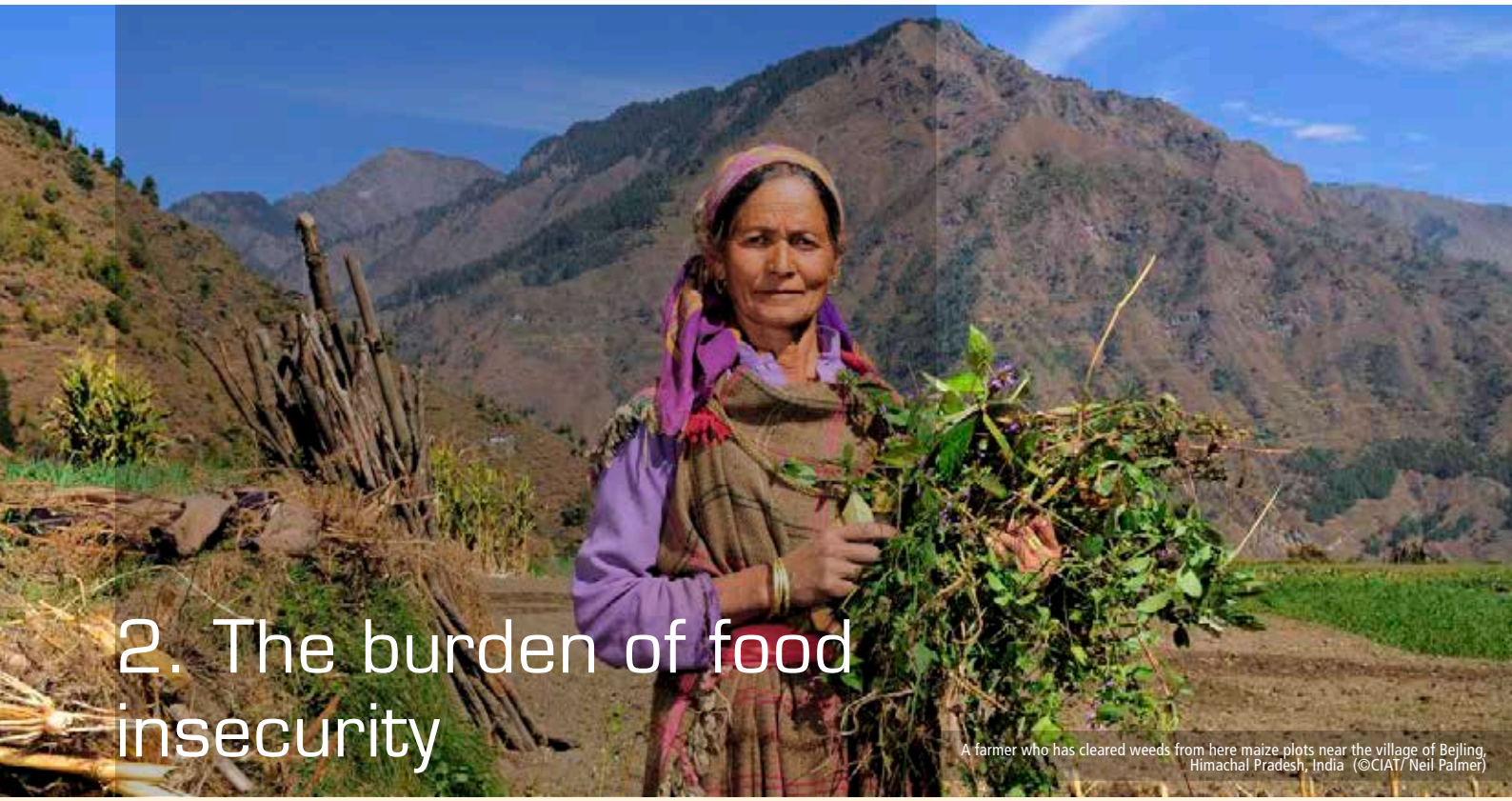
Region/subregion	2012 Share of urban mountain population out of total mountain population (%)						
	Class 1	Class 2	Class 3	Class 4	Class 5	Class 6	Total
Developing countries	**0**	**24**	**37**	**21**	**30**	**28**	**27**
Africa	0	0	8	13	16	22	16
Eastern Africa	0	0	9	10	12	12	10
Middle Africa	0	0	0	9	21	17	16
Northern Africa	-	0	0	1	28	34	31
Southern Africa	-	-	0	85	26	32	39
Western Africa	-	-	-	0	20	18	18
Latin America & the Caribbean	0	38	72	60	66	61	62
Caribbean	-	-	0	1	17	21	20
Central America	0	0	54	61	65	52	58
South America	0	38	77	57	69	71	67
Asia	0	1	2	16	28	22	21
Central Asia	0	0	0	10	18	54	38
Eastern Asia	0	1	2	11	16	13	13
South-Eastern Asia	0	0	0	6	15	17	16
Southern Asia	0	1	1	22	44	23	27
Western Asia	-	0	12	19	38	53	41
Oceania	-	0	0	8	2	3	6
Melanesia	-	0	0	8	2	2	6
Micronesia	-	-	-	-	-	28	28
Polynesia	-	-	-	0	0	32	32
Developed countries	**-**	**2**	**34**	**61**	**52**	**54**	**54**
World	**0**	**24**	**37**	**22**	**30**	**32**	**30**

Table 7. Share of mountain population living in urban areas out of total mountain population by region/subregion and elevation class in 2012

2

Measuring of food insecurity

Two men from Abu Nashab Salama, North Darfur, Sudan (©UN Photo/Albert Gonzalez Farran)



2. The burden of food insecurity

A farmer who has cleared weeds from here maize plots near the village of Bejling, Himachal Pradesh, India (©CIAT/ Neil Palmer)

Methodology

Due to the lack of disaggregated data, it has not been possible to apply any existing methodology to mountain areas to estimate their vulnerability to food insecurity. Thus, in order to quantify the number of mountain peoples vulnerable to the risk of food insecurity, the MPS coordinated a long and thorough consultation among FAO and external experts of mountain development, nutrition, statistics, livestock and GIS techniques, which led to the formulation of a model able to provide the most accurate possible estimate given the technologies and data available.

The new model was developed and applied to both 2000 and 2012 data, so as to assess the current situation and depict any trends that emerged in the 12-year period. Data for 2000 have been recalculated to have a consistency in the methodology and thus allow for a comparison.

Both the previous FAO 2003 model and the current FAO 2015 model define vulnerability for rural and urban mountain populations. For rural people, the two models' definitions are based on caloric requirement per day, while for urban populations the models use the World Bank urban poverty indicator.

The 2003 FAO Model, used in the 2003 FAO report *Towards a GIS-based analysis of mountain environments and populations,* indicated that vulnerability affected:

- rural mountain people living in areas where cereal production was less than 200 kg per person and bovine density index was medium to low
- 15 percent of urban mountain people
- all people living in closed forests and protected areas.

The 2015 FAO 2015 Model indicates that vulnerability affects:

- rural mountain people living in areas where less than 1 370 kcals and 14 g of proteins are available per person per day
- 23.6 percent of urban mountain people.

The model has been applied to developing countries only. In fact, it is suitable for areas where agriculture tends to be the prominent activity, as it doesn't capture the service industry. For example, the model would find that areas where tourism or mining activities are prominent in income generation but agriculture is almost absent are vulnerable.

The 2015 FAO Model in detail

The 2015 model builds on the framework established in the 2003 model, adding more information to better capture the factors that contribute to ensuring food security in the specific mountain context.

In view of the geographic focus of this study, the model was applied only to mountain areas. All the masks mentioned below were overlaid with the 2014 global map of mountains developed by Center for Development and Environment (CDE). Map 1 follows the UNEP-WCMC classification of mountains referenced throughout this publication.

The following paragraphs look at the various aspects that the model used to determine the vulnerability of mountain populations to food insecurity.

Population: rural and urban distinction

As with the 2003 model, the 2015 model distinguishes between urban and rural inhabitants, and the intrinsically different elements that drive their exposure to food insecurity. While rural mountain areas still rely mainly on agriculture – including husbandry and forestry – and usually face isolation, poor infrastructure and low trade opportunities, mountain cities present a scenario comparable with any other urban areas.

The sources for population data were the FAOSTAT and LandScan™, the finest population distribution model available (Oak Ridge National Laboratory).

Fundación Cordillera Tropical volunteers work together to repair a remote road, providing access for a tractor to transport 5 000 seedlings up to the planting site. Upper Mazar watershed, Cañar Province, Ecuador (©Fundación Cordillera Tropical)

Criteria for rural population: calorie and protein availability

For the rural population, the model analyses nutrients coming from a selection of staple crops and livestock to determine if minimum quantitative and qualitative dietary requirements are met. The model uses calories to evaluate the quantitative component and animal proteins to assess the qualitative one. If less than 1 370 calories and 14 g of protein are available per person per day, the population in the area is considered to be vulnerable to food insecurity. Thus, the model identifies rural areas where the output of agriculture and animal husbandry is not enough to provide inhabitants with the minimum requirements.

Thousands of people have been displaced following looting and destruction in a number of villages in South Darfur (©UN Photo/Albert González Farran)

Identification of thresholds

International dietary guidelines jointly developed by World Health Organization (WHO), FAO and United Nations University (UNU) on levels of energy and protein consumption suggest that the daily intake of energy needed by an adult varies from 1 680 to 1 990 kilocalories (Kcals), depending on the country. They also set the safe level of protein consumption at about 58 g per adult per day.

A lower threshold for energy requirements was set for the present study, because it was assumed that other foods would be eaten to meet the remainder of daily energy requirements. The 1 370 calories limit is taken as a survival requirement in the event other foods are not available, as a threshold to avoid starving. In fact, if other foods are lacking and consumption of the major staples falls below 1 370 calories per person per day, weight loss and eventually wasting will occur. Hence, the established threshold is considered a reasonable cut-off, as it provides enough to stave off starvation, but not necessarily enough – and certainly not enough on its own – to stave off food insecurity. Following the same approach, the model sets the threshold for safe animal protein consumption at 14 g, so as to take into account the fact that people have sources of proteins available other than the animal ones captured by the model.

Estimation of calorie availability

To estimate an average production rate for each area, the model considers yields of six main crops important to mountain agriculture: beans, cassava, maize, potatoes, rice and wheat. The selection, based on analysis of national production data, excludes cash crops and species unfit for cultivation in mountain areas.

A farmer showing cardamom seeds. Salekpur village, Ilam, Nepal (©Gitta Shrestha)

The FAO Global Land Cover (GLC-SHARE) map, used to identify cultivated areas, identifies locations of fields, but does not provide information on what is actually harvested. The analysis was carried out at 1 km pixel resolution and, thanks to GLC-SHARE, it was possible to learn which percentage of each pixel was covered by agricultural areas. Pixels were then aggregated into four main classes of agricultural coverage according to the percentage (25-50-75-100 percent) of cultivated areas within the pixel.

The production per country of the six selected crops were derived from the Spatial Production Allocation Model (SPAM), which provided information on the kg/ha of each crop. Yields were then converted into Kcal/ha using the chart of nutrient values developed by the FAO Nutrition Division.

The two maps were overlaid so as to obtain the average production of the area expressed in calories.

In other words, the average yield of production in calories of each pixel was multiplied by its cultivated area so to compute the estimated total amount of calories available in each pixel. Finally, the total amount of calories of each pixel was divided by the population of this pixel.

Estimation of protein availability

Protein availability is derived from livestock data. As a consequence, it only includes animal proteins. The maps of global livestock distribution, prepared by the FAO Livestock Information, Sector Analysis and Policy Branch (AGAL), were used to estimate the number of live animals per pixel. Cattle, sheep, goats and chicken were the animal species selected for this study, which considered both meat production and other products for each species. Therefore, food items included: beef meat, cow milk, sheep meat, sheep milk, goat meat, goat milk, pig meat, chicken meat and eggs. Starting from the average unitary production data (yield) per head of livestock and by country available in the FAOSTAT database, the edible portion coming from each animal was computed and then converted into proteins. Data for milk and egg production were added where relevant, and the distinction between milking and non-milking animals was considered. Finally, country data on protein availability per head of cattle were summarized into subregional averages and allocated to each animal present on the global mask. Allocating the values of protein derived from each animal allowed for summarizing the total protein available per pixel and estimating the availability of protein in each pixel. Again, the total amount of proteins of each pixel was divided by the population of this pixel.

Bedouin village in Egypt (©Flickr/Lee Royal)

Criteria for urban population: poverty headcount ratio at urban poverty line

For assessing vulnerability of the urban populations of mountain areas, the model used a World Bank World Development Indicator (WDI): the poverty headcount ratio at urban poverty line. This indicator is available at the country level only, but it was applied to urban mountainous areas as their poverty levels were assumed to be at least as high as the national poverty level. Urban poverty rate reflects the percentage of the urban population living below the national urban poverty line and is usually estimated on an annual basis. For each developing country, the average urban poverty rate registered from 1998 to 2000 and 2010 to 2012 was calculated, and the values synthetized in unique averages for all developing countries. This approach found that 25.9 percent of the urban mountain population was vulnerable to food insecurity in 2000 and 23.6 percent in 2012.

The issue of closed forests and protected areas

While the FAO 2003 analysis considered all people living in closed forests and protected areas as vulnerable, the new 2015 model does not maintain this criterion. The topic of protected areas is often controversial and thus has been carefully inspected. In principle, protected areas exist to achieve the long term conservation of nature with associated ecosystem services and cultural values. Millions of people depend on them and the access to their natural resources as a means of subsistence. When establishment of protected areas weakens or extinguishes legitimate tenure rights of local communities, this can result in increased hunger, poverty, displacement and social conflict. In order for protected

A farmer woman in Yangshuo County, China (©Flickr/ Dimitry B.)

areas to contribute not only to conservation objectives but also to food security and sustainable livelihoods, it is necessary to apply principles of responsible governance of tenure and equitable access to resources. When these principles are observed, the livelihoods of local people are not hampered and may eventually be improved. On account of this, the present study did not adopt any dedicated criteria to target people living in protected areas or in closed forests.

Peruvian woman in traditional clothing with alpaca (©Flickr/ rickz)

Comparison between the FAO 2003 and FAO 2015 models

In summary, the new FAO 2015 methodology offers several improvements with respect to the model previously used. By looking at both calories and proteins, it introduces the concept of dietary quality into the analysis while, before, only quantity had been assessed. In addition, calories from six staple crops (beans, cassava, maize, potatoes, rice and wheat) are examined instead of just cereal production. This better reflects the mountain diet.

Finally, proteins from multiple livestock products (beef meat, cow milk, sheep meat, sheep milk, goat meat, goat milk, pig meat, chicken meat and eggs) are grouped together instead of considering bovine density only. Again, this provides an estimate closer to reality.

Limits of the model

Developing the model was a great challenge because of the global scale of the analysis. Homogeneous and disaggregated (subnational/local) data are scarce, as data usually are gathered or disclosed at the country level. Moreover, many data were not updated regularly or at all over the period of time under consideration. Accordingly, several assumptions had to be made to build this model. Case studies based on household surveys were undertaken in Ecuador and Malawi (see Section III). They are included in this report to illustrate what could be achieved if georeferenced household data were available for all countries.

In order to perform the global analysis, it was decided to use a GIS-based model and develop a dedicated methodology. When local data were missing, values were replaced by the subregional average calculated on mountain areas only. This happened, for example, when working on the crop component. GLC-Share, the source of information on cultivated land, tells where fields are located but not what is actually harvested there. SPAM is a global mask that provides yield for all crops that might be harvested in each area. There are some cases where GLC-Share signals an agricultural land cover, but SPAM has no yields available for crops in that area. In those cases, to estimate field yields, the study applied the average yield recorded in mountain areas of its subregion. The same was done for the livestock component, *i.e.* when yields for a given country were missing in FAOSTAT, the subregional mountain average was applied.

A paniramic view of a mountain range area sorrounding farmland in the Betroka Region, Southern Madagascar. (©FAO/Yasuyoshi Chiba)

Being a model based on multiple assumptions and adapted to the global scale, its findings should not be considered for their significance at a pixel level (the 30 arc-second grid pixel used for the analysis is approximately 1 square kilometre). Instead, they provide estimates at a larger scale. The model considers that all agricultural production is converted into food for human consumption. In reality, this is often not the case. Nevertheless, the assumption is that if production is used to feed livestock or sold, it will ensure farmers have alternative food source or generate additional income, so in the end they prevent the exposure to food insecurity anyway.

The model does not capture productive activities other than agriculture and animal husbandry. It is acknowledged that the sources of income of mountain households are most likely wider. In fact, forestry, tourism and mining are just a few examples of activities that may complement the livelihoods of mountain people, together with the remittances that are sent by migrated mountain people. Unfortunately, for the time being, it is impossible to appraise their value and find information globally. This limitation of the model is something that needs to be addressed with future data collection.

On the global scale, there is a lack of disaggregated information even on the sociodemographic structure of the mountain population. Almost no data specifying gender, age, literacy or employment is available at the global level. All that is known is the total count – how many human beings live in the mountains. Again, such additional information would tremendously enrich the analysis.

Framers harvest potatoes in Bangao, Buguias, Benguet, Philippines (©IFAD/GMB Akash)

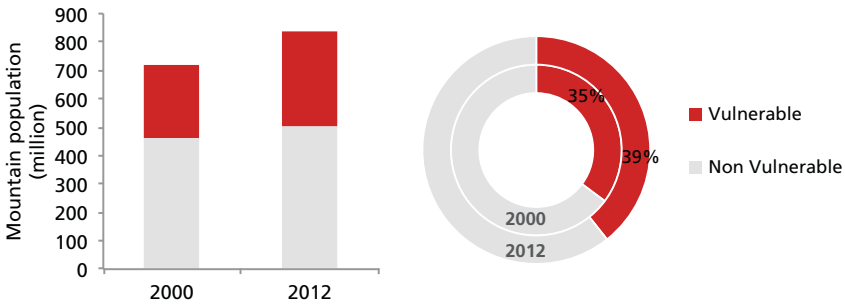
Estimate of vulnerable mountain people in developing countries

Vulnerability trends in developing countries

In the 12 years from 2000 to 2012, the number of people vulnerable to food insecurity increased in the mountain areas of developing countries across the world. In 2000, more than 250 million people living in mountain areas were considered vulnerable to food insecurity, representing about 35 percent of the mountain population of developing countries at that time. By 2012, the study found the number of vulnerable mountain people had increased 30 percent, while the mountain population itself had increased just 16 percent. This meant that vulnerability had increased to include nearly 329 million people – a number corresponding to 39 percent of the 2012 mountain population (Table 8; Figure 10A, 10B).

Condition	Number of mountain people ('000)		Percentage change 2000-2012 (%)	Share (%)	
	2000	2012		2000	2012
Vulnerable	252 507	328 516	**30**	35	39
Non vulnerable	465 194	506 598	**9**	65	61
Total	**717 702**	**835 114**	**16**	**100**	**100**

Table 8. Vulnerable and non vulnerable mountain people living in developing countries in 2000 and 2012

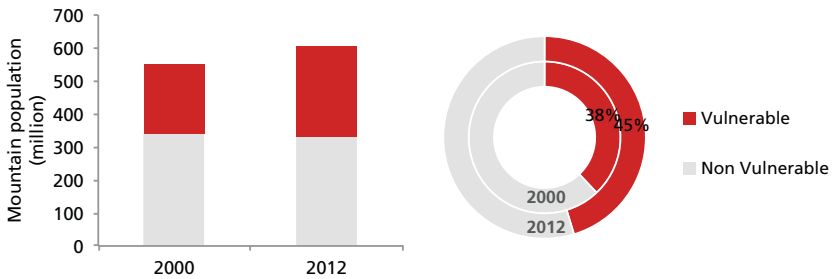


Figures 10A and 10B. Vulnerable and non vulnerable mountain people living in developing countries in 2000 and 2012

Focusing on rural mountain populations only, the degree of vulnerability along the 12-year timeline increased by 31 percent – from 209 million people (38 percent) in 2000 to 274 million (45 percent) in 2012, while rural mountain population increased by only 10 percent in the same period (Table 9; Figure 11A, 11B).

Condition	Number of mountain people ('000)		Percentage change 2000-2012 (%)	Share (%)	
	2000	2012		2000	2012
Vulnerable	209 401	274 272	**31**	38	45
Non vulnerable	342 059	331 190	**-3**	62	55
Total	**551 460**	**605 462**	**10**	**100**	**100**

Table 9. Rural vulnerable and non vulnerable mountain people living in developing countries in 2000 and 2012



Figures 11A and 11B. Rural vulnerable and non vulnerable mountain people living in developing countries in 2000 and 2012

This increase was not spread equally across all mountain regions, and some differences were also detected at the subregional levels (Table 10, 11).

Region/ subregion	2000 Vulnerable mountain people ('000)							Vulnerable mountain people out of total mountain population (%)
	Class 1	Class 2	Class 3	Class 4	Class 5	Class 6	Total	
Developing countries	**2 756**	**4 462**	**16 832**	**56 044**	**53 024**	**119 389**	**252 507**	**35**
Africa	0.927	139	4 652	22 532	15 482	16 048	58 854	40
Eastern Africa	0.761	137	4 377	18 535	10 146	5 601	38 796	40
Middle Africa	0.166	2	230	2 847	3 052	3 477	9 608	63
Northern Africa	-	-	3	308	965	3 075	4 351	29
Southern Africa	-	-	43	825	1 092	1 391	3 351	29
Western Africa	-	-	-	17	226	2 504	2 747	34
Latin America & the Caribbean	569	2 296	6 817	8 133	5 891	15 406	39 112	30
Caribbean	-	-	0.314	31	128	1 548	1 706	50
Central America	1	60	2 507	5 946	3 378	5 559	17 451	34
South America	567	2 236	4 309	2 156	2 386	8 299	19 954	27
Asia	2 187	2 024	5 139	24 463	31 371	87 380	152 564	35
Central Asia	4	106	76	276	499	1 062	2 023	28
Eastern Asia	1 104	950	2 276	14 437	16 936	48 746	84 449	35
South-Eastern Asia	0.504	12	60	823	3 063	14 297	18 257	36
Southern Asia	1 079	956	1 806	6 205	7 731	17 403	35 181	38
Western Asia	-	0.004	921	2 721	3 141	5 872	12 655	28
Oceania	-	3	223	916	280	555	1 977	77
Melanesia	-	3	223	916	280	555	1 976	78
Micronesia	-	-	-	-	-	0.024	0.024	1
Polynesia	-	-	-	-	0.005	0.746	0.752	4

Table 10. Global overview of vulnerable mountain people living in developing countries in 2000 by region/subregion and elevation class

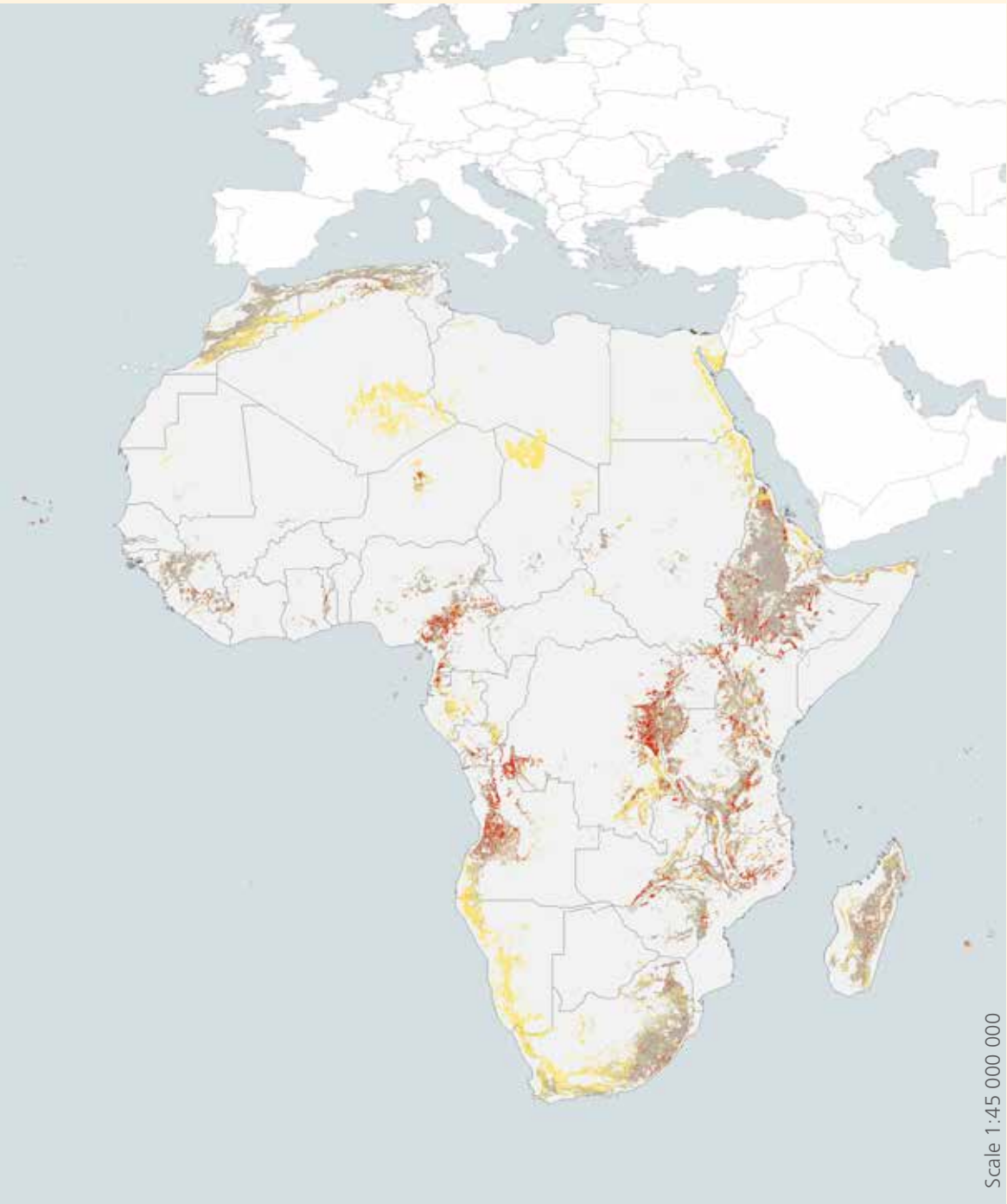
Region/ subregion	2012 Vulnerable mountain people ('000)							Vulnerable mountain people out of total mountain population (%)
	Class 1	Class 2	Class 3	Class 4	Class 5	Class 6	Total	
Developing countries	**1 405**	**4 264**	**20 715**	**79 803**	**74 133**	**148 194**	**328 516**	**39**
Africa	0.641	170	5 899	33 185	22 125	24 381	85 760	42
Eastern Africa	0.521	166	5 701	27 208	14 958	8 127	56 161	41
Middle Africa	0.120	4	147	4 365	4 053	4 923	13 492	64
Northern Africa	-	-	3	302	1 344	5 317	6 966	35
Southern Africa	-	-	47	1 268	1 454	2 299	5 069	33
Western Africa	-	-	-	42	316	3 714	4 072	38
Latin America & the Caribbean	303	1 998	8 044	9 936	7 740	19 784	47 805	31
Caribbean	-	-	0.152	48	196	1 839	2 083	45
Central America	0.040	21	2 338	7 125	4 486	7 028	20 998	34
South America	303	1 977	5 706	2 762	3 059	10 917	24 723	27
Asia	1 102	2 095	6 573	35 277	43 976	103 755	192 778	41
Central Asia	11	22	74	493	975	1 561	3 136	34
Eastern Asia	920	1 440	3 022	17 214	19 635	51 363	93 595	42
South-Eastern Asia	0.312	135	244	1 064	4 356	15 734	21 532	41
Southern Asia	171	497	2 334	11 486	13 840	25 822	54 150	42
Western Asia	-	-	899	5 020	5 170	9 275	20 364	34
Oceania	-	2	199	1 405	293	274	2 173	69
Melanesia	-	2	199	1 405	293	273	2 172	69
Micronesia	-	-	-	-	-	0.013	0.013	7
Polynesia	-	-	-	-	-	0.715	0.715	8

Table 11. Global overview of vulnerable mountain people living in developing countries in 2012 by region/subregion and elevation class

The following examines mountain peoples' vulnerability to food insecurity by region.

Africa

Almost 59 million mountain people in the African region were identified as vulnerable to food insecurity in 2000, a number that increased 46 percent – to 86 million – by 2012 (Table 12; Figure 12A; Map 3). This increase reflects in part the 38 percent increase in the overall African mountain population. The majority of vulnerable people are still located in the eastern Africa subregion, which accounts for 65 percent of the total, and increased by 45 percent between 2000 and 2012 (Figure 12B). However, the proportion of vulnerable people in this region remained quite stable from 2000 to 2012, passing from 40 to 41 percent of the local mountain population. Middle Africa, the subregion with the highest proportion of vulnerable local populations, grew from 63 to 64 percent of the local mountain population. A clearer increasing trend in vulnerability was observed in northern Africa, where the percentage of vulnerable mountain people went from 29 percent in 2000 to 35 percent in 2012, as well as in western and southern Africa (Table 12).



Vulnerability of people to food insecurity in the rural mountain areas of developing countries in Africa in 2012

- Vulnerable mountain areas
- Non vulnerable mountain areas
- Unhabitated mountain areas

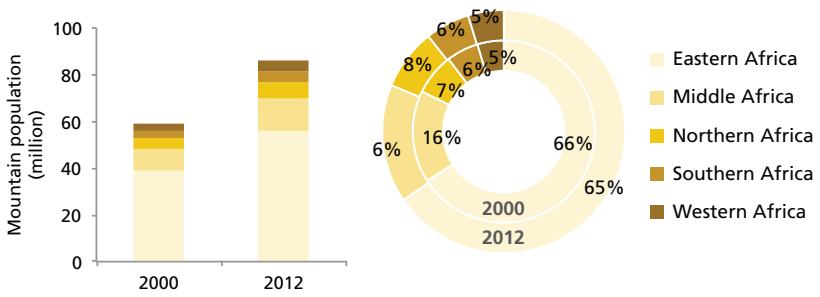
Map 3. Distribution of vulnerable rural mountain population living in the African region in 2012

How to read vulnerability on the regional maps

Maps provide a graphic overview rather than punctual information and shall not be interpreted at the pixel level.

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
Eastern Africa	38 796	56 161	**45**	66	65	40	41
Middle Africa	9 608	13 492	**40**	16	16	63	64
Northern Africa	4 351	6 966	**60**	7	8	29	35
Southern Africa	3 351	5 069	**51**	6	6	29	33
Western Africa	2 747	4 072	**48**	5	5	34	38
Total	**58 854**	**85 760**	**46**	**100**	**100**	**40**	**42**

Table 12. Vulnerable mountain people living in Africa in 2000 and 2012

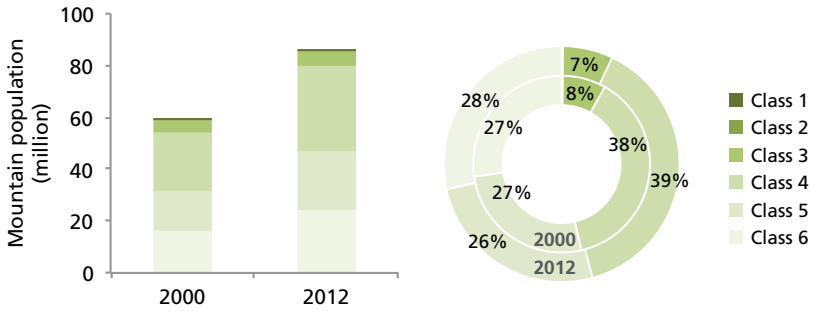


Figures 12A and 12B. Vulnerable mountain people living in Africa in 2000 and 2012

The increase in vulnerability among African mountain populations is correlated with altitude, with the lowest elevation classes experiencing the highest increments of vulnerability (Table 13; Figure 13A). Mountain areas between 300 and 1 000 m (Class 6) saw the number of vulnerable people rise 52 percent in 12 years, passing from 16 to 24 million. More than 33 million people living between 1 500 and 2 500 m were considered vulnerable to food insecurity in 2012, which was an increase of 11 million people, or 47 percent, in 12 years. On the other hand, there were fewer vulnerable people living at the highest altitudes (>3 500 m) in 2012 than in 2000. However, this was likely a consequence of the overall decrease in mountain population at those elevations, which are the ones usually experiencing the strongest outmigration phenomena. Interestingly, the share of vulnerable people living between 2 500 m and 3 500 m decreased in spite of a slight increase in the number of vulnerable people at the same elevation between 2000 and 2012. The distribution of vulnerable mountain people among the six elevation classes traced the distribution of mountain population (Table 4, 5) and remained quite stable (Table 13; Figure 13B).

Elevation	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
Class 1	0.9	0.6	**-31**	0.002	0.001	100	100
Class 2	139	170	**22**	0.2	0.2	56	48
Class 3	4 652	5 899	**27**	8	7	38	36
Class 4	22 532	33 185	**47**	38	39	40	43
Class 5	15 482	22 125	**43**	26	26	43	44
Class 6	16 048	24 381	**52**	27	28	39	42
Total	**58 854**	**85 760**	**46**	**100**	**100**	**40**	**42**

Table 13. Vulnerable mountain people living in Africa in 2000 and 2012 by elevation class



Figures 13A and 13B. Vulnerable mountain people living in Africa in 2000 and 2012 by elevation class

Latin America and the Caribbean

In Latin America and the Caribbean, the number of vulnerable mountain people increased from more than 39 million in 2000 to nearly 48 million in 2012, an increase of 22 percent (Table 14; Figure 14A, 14B; Map 4). However, the proportion of vulnerable mountain populations remained quite stable, passing from 30 to 31 percent in 12 years. The majority of vulnerable people (52 percent) lived in South America, mainly located between 300 and 1 000 m (Class 6), although almost 10 million vulnerable people lived above 2 500 m (Classes 1, 2 and 3) in 2012. Populations living at the highest altitudes (Class 1) had a 47 percent decrease in the number of vulnerable people, probably due to outmigration from those areas (Table 15; Figure 15A, 15B). On the other hand, there was a slight increase in the number of vulnerable people living between 1 500 m and 3 500 m (Classes 3 and 4), in spite of a decrease in the share of vulnerable people out of total mountain people at the same elevations. In both South and Central America, the proportion of vulnerable people remained unchanged between 2000 and 2012.

Residents of the Kichwa-Cañari community work together to create a school garden that will provide fresh produce for their children. Huangras, Cañar Province, Ecuador (©Fundación Cordillera Tropical)

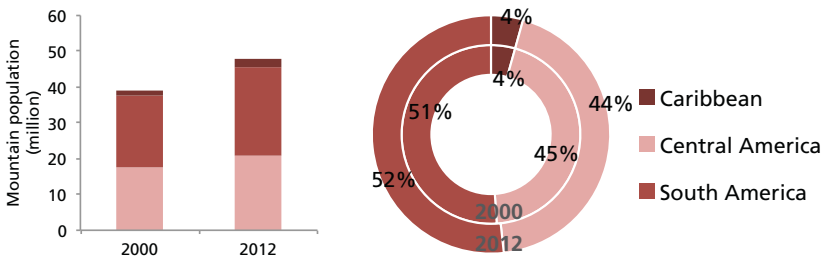
Vulnerability of people to food insecurity in the rural mountain areas of developing countries in Latin America and the Caribbean in 2012

- Vulnerable mountain areas
- Non vulnerable mountain areas
- Unhabitated mountain areas

Map 4. Distribution of vulnerable rural mountain population living in Latin America and Caribbean 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
Caribbean	1 706	2 083	**22**	4	4	50	45
Central America	17 451	20 998	**20**	45	44	34	34
South America	19 954	24 723	**24**	51	52	27	27
Total	**39 112**	**47 805**	**22**	**100**	**100**	**30**	**31**

Table 14. Vulnerable mountain people living in Latin America and the Caribbean in 2000 and 2012



Figures 14A and 14B. Vulnerable mountain people living in Latin America and the Caribbean in 2000 and 2012

Elevation	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
Class 1	569	303	**-47**	1.4	0.6	54	40
Class 2	2 296	1 998	**-13**	6	4	30	24
Class 3	6 817	8 044	**18**	17	17	31	28
Class 4	8 133	9 936	**22**	21	21	34	33
Class 5	5 891	7 740	**31**	15	16	30	32
Class 6	15 406	19 784	**28**	39	41	28	31
Total	**39 112**	**47 805**	**22**	**100**	**100**	**30**	**31**

Table 15. Vulnerable mountain people living in Latin America and the Caribbean in 2000 and 2012 by elevation class

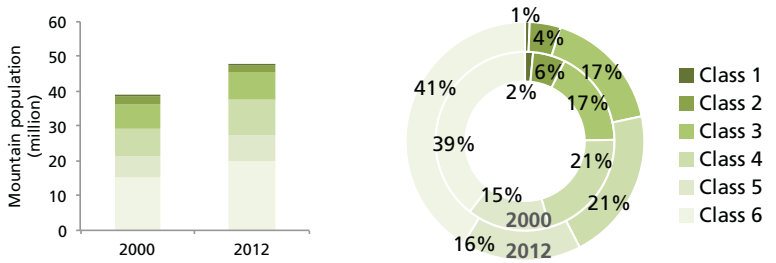
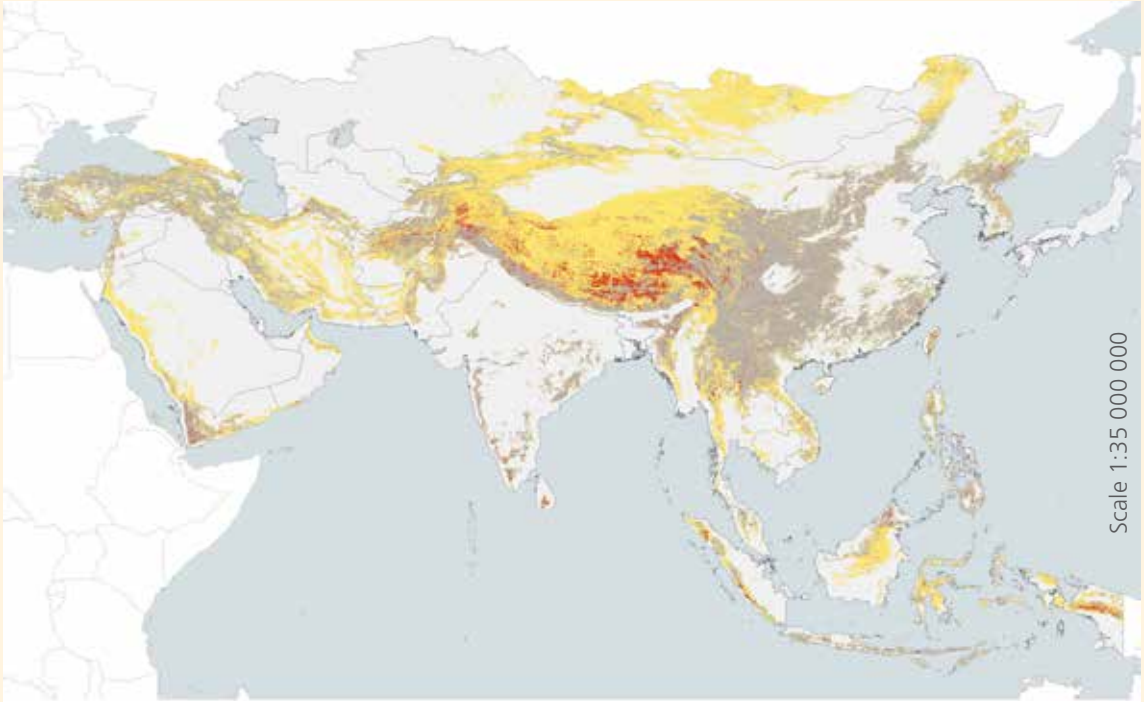


Figure 15A and 15B. Vulnerable mountain people living in Latin America and the Caribbean in 2000 and 2012 by elevation class

Asia

Mountain populations of Asia are particularly prone to vulnerability. Results show that more than 192 million people were considered vulnerable to food insecurity in 2012, an increase of over 40 million people, or 26 percent, from 2000 (Table 16; Figure 16A; Map 5). This mainly occurred in Central, Southern and Western Asia, where the increase in the number of vulnerable people exceeded 50 percent. The study also found the proportion of vulnerable people among mountain populations grew from 35 to 41 percent, more or less equally spread among the five subregions. In 2000, Eastern Asian populations represented the majority (55 percent) of vulnerable mountain people of Asia, with more than 84 million individuals affected. This situation persisted in 2012, when 93 million people in Eastern Asia were vulnerable to food insecurity, although the share of Eastern Asian vulnerable people among the other regions decreased to 49 percent. (Table 16; Figure 16B).



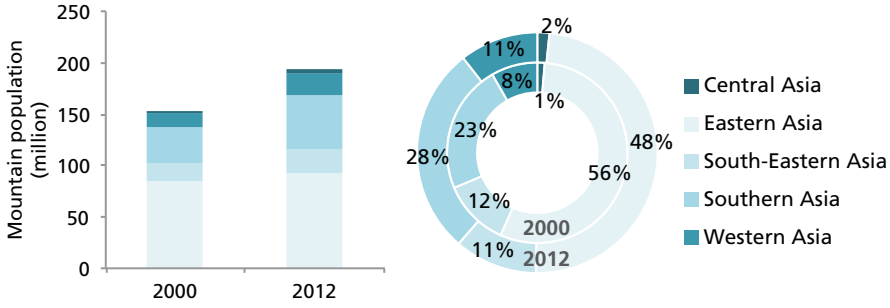
Vulnerability of people to food insecurity in the rural mountain areas of developing countries in Asia in 2012

Vulnerable mountain areas
Non vulnerable mountain areas
Unhabitated mountain areas

Map 5. Distribution of vulnerable rural mountain population living in the 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**

Table 16. Vulnerable mountain people living in Asia in 2000 and 2012



Figures 16A and 16B. Vulnerable mountain people living in Asia in 2000 and 2012

In 2000, 87 million people living below 1 000 m (Class 6) were vulnerable to food insecurity, accounting for 57 percent of Asian vulnerable mountain population. The majority (54 percent) of vulnerable people lived below 1 000 m in 2012, although a slight increase was observed at higher altitudes (Classes 3, 4 and 5). The share of vulnerable people among mountain populations of Asia in 2012 scored between 39 and 45 percent at all elevation classes, with the exception of the highest – in which it reached 64 percent of the mountain population. On the other hand, as in all the other regions, populations living above 4 500m (Class 1) saw a strong, 50 percent decrease in vulnerability in 12 years, probably as a consequence of depopulation, which is a global trend at these altitudes (Table 17; Figure 17A, 17B).

Elevation	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
Class 1	2 187	1 102	**-50**	1.4	0.57	81	64
Class 2	2 024	2 095	**3.5**	1.3	1.1	42	45
Class 3	5 139	6 573	**28**	3	3	37	44
Class 4	24 463	35 277	**44**	16	18	35	43
Class 5	31 371	43 976	**40**	21	23	33	39
Class 6	87 380	103 755	**19**	57	54	35	40
Total	**152 564**	**192 778**	**26**	**100**	**100**	**35**	**41**

Table 17. Vulnerable mountain people living in Asia in 2000 and 2012 by elevation class

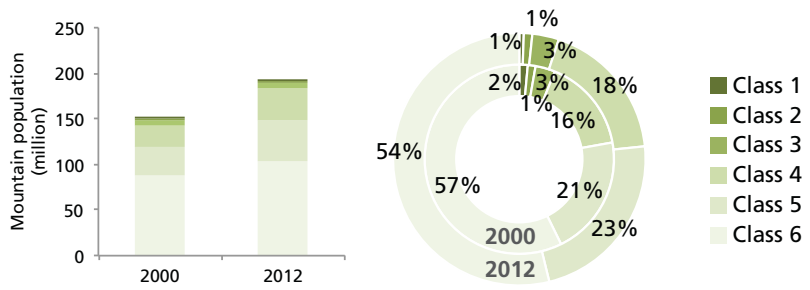


Figure 17A and 17B. Vulnerable mountain people living in Asia in 2000 and 2012 by elevation class

Oceania

Oceania is a delicate case to analyse, as its mountain territory covers just 229 000 km^2 and its overall mountain population includes only 3 million people. Thus, small variations in the demographic figures may result in high percentage variations.

In 2000, less than 2 million people, corresponding to 77 percent of mountain population, were considered vulnerable. By 2012, the number had increased 10 percent to more than 2 million, corresponding to a 23 percent increase in mountain population between 2000 and 2012. Despite this, the share of vulnerable people out of the total mountain population dropped to 69 percent. Nearly all the mountain populations of Oceania were located in the Melanesian subregion, which also had the highest number of vulnerable mountain people (Table 18; Map 6).

Vulnerability of people to food insecurity in the rural mountain areas of developing countries in Oceania in 2012

Vulnerable mountain areas
Non vulnerable mountain areas
Unhabitated mountain areas

Map 6. Distribution of vulnerable rural mountain population living in the Oceanian developing countries 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
Melanesia	1 976	2 172	**10**	100	100	78	69
Micronesia	0.024	0.013	**-47**	0.001	0.001	0.7	7
Polynesia	0.752	0.715	**-5**	0.04	0.03	4	8
Total	**1 977**	**2 173**	**10**	**100**	**100**	**77**	**69**

Table 18. Vulnerable mountain people living in Oceania in 2000 and 2012

A view of different elevation classes indicates a major variation in the trend of vulnerability in Oceania (Table 19). In 2012, nearly 1.5 million individuals living between 1 500 and 2 500 m (Class 4) were found to be vulnerable to food insecurity, an increase of 54 percent in 12 years.

However, Class 6 (300 – 1 000 m) and Class 2 (3 500 – 4 500 m) had 50 percent decreases in the number of vulnerable people but, at the same time, experienced great reductions in total populations. In fact, 93 percent of those left in 2012 were vulnerable to food insecurity, compared to 89 percent in 2000.

Elevation	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
Class 1	0	0	**0**	0	0	0	0
Class 2	3	1.5	**-50**	0.15	0.07	89	93
Class 3	223	199	**-11**	11	9	95	89
Class 4	915	1 405	**54**	46	65	80	75
Class 5	280	293	**5**	14	13	73	61
Class 6	555	274	**-51**	28	13	70	49
Total	**1 977**	**2 173**	**10**	**100**	**100**	**77**	**69**

Table 19. Vulnerable mountain people living in Oceania in 2000 and 2012 by elevation class

Overall findings on vulnerability in mountains

If the global picture is considered, 1 out of 3 mountain people in developing countries is vulnerable to food insecurity. The data is obviously alarming, and even more so if compared with the FAO global estimate of the percentage of people suffering from chronic hunger for the same countries, which is 1 out of 8 people.

This figure gives voice to the plight of mountain peoples. It also helps explain why many mountain dwellers have been or will be forced to abandon their homelands and outmigrate in search of better living conditions and job opportunities. This is clearly illustrated in the regional maps (Maps 3, 4, 5, 6) which identify the enormous areas already abandoned by vulnerable people who faced situations so dramatic they had to leave. Their migration, in turn, increased the pressure on already poor areas where they settled – increasing the populations and exacerbating the vulnerability to food insecurity of all.

This should send a strong message to policy-makers on the need to include mountain development in their agendas – development aimed at alleviating the harsh living conditions of mountain inhabitants and slow outmigration from mountain areas. Losing population in these areas will result in an inestimable loss in terms of provision of ecosystem services and preservation of cultural and agrobiological diversity.

Kho Muong village, Vietnam (©Flickr/Peter Garnhum)

3

Household surveys: zooming in to assess vulnerability to food insecurity

Malawian landscape (©Flickr/Rowley Taylor)

3. Household surveys: zooming in to assess vulnerability to food insecurity

Farmers waiting for transportation on the side of the road in Taipicha, near Turpo, Peru (©IFAD/Pablo Corral Vega)

Methodology

This section presents a new approach for estimating mountain peoples' vulnerability to food insecurity starting from household survey data. In addition to crop and livestock activities, this approach includes other factors impacting food security such as water quality, sanitation facilities and road networks, allowing for a holistic assessment of vulnerability to food insecurity. Thus, the methodology used in these case studies allows for greater differentiation among vulnerable areas, as it can depict also when vulnerability factors like poor water quality or isolation of rural communities play a major role. This approach has huge potential, as it builds upon a wide range of information collected at the household level and allows for the precise localization of vulnerability hotspots. This, in turn, helps target and facilitate policy interventions. For this study, the methodology was applied to two pilot countries, Ecuador and Malawi, where mountain areas present different socio-economic characteristics: while Ecuador is an "upper middle-income" country where mountain people are concentrated in urban areas, Malawi is a "low income – food insecure country" where mountain people are mostly rural.

Each case study first presents the main findings obtained from survey data in terms of living conditions, food consumption patterns[1] and exposure to food insecurity of the populations living in the different elevation classes. It then introduces the newly developed "composite vulnerability indicator (CVI)" which takes into account the dimensions of food security that are relevant at the household level as well as social protection measures. Finally, each case study provides an estimate of vulnerability to food insecurity of mountain people by elevation class and ethnic group.

1 Food consumption statistics were obtained through ADePT-FSM, a software package jointly developed by FAO and the World Bank to produce food security indicators from food consumption data collected in household surveys.

Vulnerability to food insecurity is related to the (in)ability to cope with external shocks that impact food and nutrition security and to come back to the original conditions once the shock is over. In order to estimate vulnerability to food insecurity, the CVI takes three food security dimensions into account:

1. *Physical access to food markets*: for isolated households, access to food markets is made difficult by the poor conditions, or even the absence, of transport infrastructure. Consequently, isolated households' food security is more affected by extreme climatic conditions and environmental shocks. In addition, the opportunities to market their own products are scarce, reducngthe potentil to improve their livelihoods. Thus, the present study considers access to improved ways of transportation, such as paved or cobbled roads, as the indicator for the physical access dimension.

2. *Economic access to food*: inadequate purchasing power is generally viewed as the main cause of food insecurity at the household level. In the new approach presented here, rural and urban households are identified as vulnerable if the following situations occur:

    a. *in rural areas:* if per capita income is below the national poverty line and the household does not own land and does not benefit from any health/job insurance scheme or subsidy programme;
    b. *in urban areas:* if per capita income is below the poverty line, or the household is not covered by any kind of health or job insurance.

3. *Utilization*: sufficient energy and nutrient intake is the result of good care and feeding practices, food preparation, dietary diversity and intra-household distribution of food. When combined with good biological utilization of food consumed, this determines the nutritional status of individuals. In this study, access to improved water sources and presence of improved sanitation facilities are used as indicators for the utilization dimension. In many cases, poor hygienic conditions and contaminated drinking water are the main determinants of health problems that may impact food utilization.

This approach considers a household "vulnerable" to food insecurity as a whole if it is vulnerable to at least one of the food security dimensions described above.

However, vulnerability can be reduced by building resilience of both people and communities, *e.g.* by adopting social safety nets in the form of policy measures meant to prevent vulnerable people from falling under certain minimum levels of livelihoods as a consequence of a shock. These are important tools that can support maintaing household food security over time.

The final figure of vulnerable people estimated by this case study will therefore exclude those "vulnerable" households that benefit from safety nets such as school feeding and food distribution programmes.

It is to be noted that the concept of vulnerability to food insecurity should not be confused with food insecurity itself. A household "vulnerable" to food insecurity may or may not experience food insecurity depending on exogenous conditions.

Ecuador

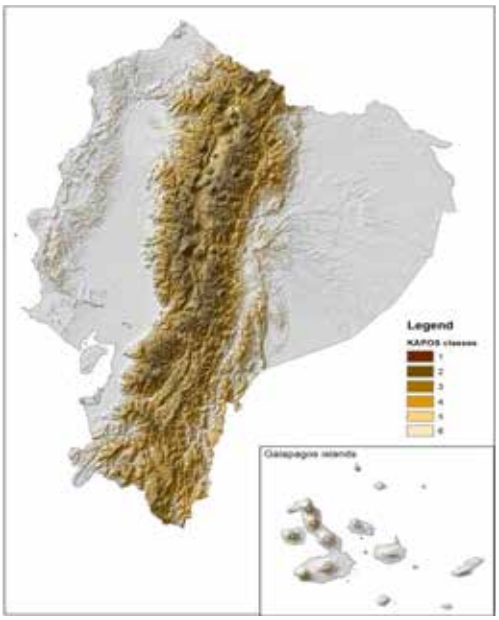


Figure 18. Mountain areas of Ecuador (CDE, University of Berne)

Ecuador is the most densely populated country of Latin America and the Caribbean, and one of the most "bio-diverse" countries in the world. With a 2014 GDP of about US$100 billion and a population of almost 16 million, it is ranked by the World Bank in the "upper middle income" group. At the time of the household survey, however, food insecurity was still an issue for around 13 percent of its population, according to the 2015 SOFI report published by FAO. The Andes, the longest mountain range in the world, crosses the country from north to south, covering 40 percent of the national territory and is home to nearly half of the total population. Due to their proximity to the equator and hence to the lack of harsh climatic conditions, elevated plateaus have been chosen throughout history as locations for major urban settlements. The capital, Quito, located at an elevation of 2 850 m (Class 3), is an urban area with infrastructure and subsidiary activities uncommon to most of the mountain areas around the world.

Data presented in this case study were gathered by the Ecuadorian National Statistics Institute (INEC) in 2011–12 through a Household Income and Expenditure Survey that involved almost 40 000 households and about 150 000 people. Matching survey data with the location of each household and the corresponding elevation allowed the study to derive household statistics by elevation class and to identify patterns in the change of living conditions and vulnerability to food insecurity in the different classes.

The study found elevation Classes 2 and 5 to have a strong rural character, with low population density and low number of cities, as opposed to Classes 3

Fundación Cordillera Tropical staff and volunteers transport seedlings to plant in pasture. Upper Mazar watershed, Cañar Province, Ecuador (©Fundación Cordillera Tropical)

and 4, which had the opposite characteristics. Classes 2 and 5 had the lowest percentages of dwellings with improved water sources and sanitation facilities, a high dependency ratio and the highest percentage of women among the elevation classes, suggesting that many adult men leave their families in search of better employment and economic conditions. This preliminary conclusion is supported by the results of the survey's "self-evaluation of living standards" module, which included questions on the causes of household poverty. In answering those questions, "unemployment" and "lack of good jobs" were the causes most frequently reported by respondents of Classes 2 and 5.

The urban character of elevation Classes 3 and 4 is reflected by higher per capita income and a lower percentage of people working in the primary sector. Class 3 has the highest percentage of people holding a University degree and the highest standards of water and sanitation facilities among the elevation classes, but is also characterized by higher income inequality and higher food prices.

As for food consumption patterns, households in the rural Classes 2 and 5 spent the highest income portion on food and had the lowest dietary diversity, measured in terms of total number of food items reported during the interview. The food group "cereals and products" contributed the most to the dietary energy and protein consumption in all elevation classes, with white rice being the biggest energy contributor among the single food items. However, the share of energy derived from cereals on total dietary energy was lower than in the country as a whole, while the share of roots, tubers and pulses was higher. In quantitative terms, milk was the most consumed food item in Classes 1 through 5, while in Class 6 and in lowlands white rice was followed by green plantains. The share of dietary energy obtained from own-produced food on total dietary energy in elevation Class 5 was higher than in all other classes. Maize was the most frequently cultivated crop in almost all elevation classes, with the exception of elevation Classes 2 (potatoes) and 6 (plantains). The mostly urban Class 3, on the other hand, obtained its highest share of calories from purchased food.

Based on the methodology described in the previous paragraph, about 5.8 million people are vulnerable to food insecurity in Ecuador, corresponding to 40 percent of total population[2], of which 2.1 million live in mountain areas (Figure 19). The share of vulnerable people to total population is lower in mountain areas

Basilica del Voto Nacional in Quito, Ecuador
(©Flickr/Jaime Golombek)

2 Population figures refer to the 2010 Population census data. Since the survey was not designed to be representative at the level of the mountain versus non mountain areas, the survey expansion factors have been recomputed to derive statistics representative of the population of the different elevation classes, based on the 2010 Census data.

(31 percent) than in lowlands (48 percent) (Table 20). In total, 19 percent of people in mountain areas have insufficient economic access to food, making economic access the food security dimension that contributes the most to the final figure of vulnerable people.

Elevation	Vulnerable people (%)	Vulnerable people ('000)	Vulnerable people (%)	Vulnerable people ('000)
Class 2 (3 500–4 500)	73	20	Urban: - Rural: 73	Urban: - Rural: 20
Class 3 (2 500–3 500)	26	1 162	Urban: 19 Rural: 38	Urban: 552 Rural: 610
Class 4 (1 500–2 500)	30	334	Urban: 24 Rural: 36	Urban: 145 Rural: 189
Class 5 (1 000–1 500)	48	121	Urban: 38 Rural: 51	Urban: 19 Rural: 102
Class 6 (300–1 000)	53	509	Urban: 46 Rural: 61	Urban: 232 Rural: 277
Mountain areas	31	2 147	Urban: 23 Rural: 43	Urban: 949 Rural: 1 198
Class 0 (0–300)	48	3 627	Urban: 39 Rural: 74	Urban: 2 171 Rural: 1 457
Ecuador	**40**	**5 774**	**Urban: 32 Rural: 55**	**Urban: 3 119 Rural: 2 655**

Table 20. Vulnerable people by elevation class in Ecuador estimated through the Composite Vulnerability Indicator (CVI)
Source: author's elaborations using ENIGHUR 2011-12 data; data on elevations and population provided by INEC.

The majority of vulnerable mountain people live in rural areas, although almost 1 million vulnerable people live in urban areas. In absolute terms, elevation Class 3 – the most densely populated elevation class of Ecuador – has the highest number of vulnerable people, located both in urban and rural areas. In elevation Class 2, the number of vulnerable people is small, but they represent 73 percent of the total population.

Two different patterns of vulnerability to food insecurity can be identified in Ecuadorian mountain areas: one of the rural areas and one of the urban areas. In rural contexts, vulnerability is often linked to isolation, poor water and sanitation infrastructures, and lack of good job and education opportunities, which contribute to outmigration to urban areas. In urban settings, vulnerability to food insecurity is

Cotopaxi view from Quito (©Flickr/Malcolm)

mainly driven by high income inequality, higher prices of food, and lack of job or health assistance, all of which can contribute to household inability to cope with food-related or economic shocks.

Sucumbíos Province in Northeast Ecuador has the highest prevalence of vulnerability to food insecurity (excluding the provinces where people are completely located in lowlands), while the western Manabí Province (fully mountainous, it is where Quito is located) has the highest number of vulnerable people in absolute terms.

Based on self-declared ethnicity, the two groups with the lowest prevalence of vulnerability to food insecurity (about 35 percent) are *Mestizo* and *Blanco*, which account for about 75 percent of the total population. Among indigenous people, on the other hand, prevalence of vulnerability is about 60 percent, and among other minorities, the prevalence is higher than the national average as well. Indigenous people (almost 1 million people) are mostly located in mountain areas, where they account for about 13 percent of the mountain population. In absolute terms, vulnerable indigenous people are mainly located in rural areas of Classes 3 and 6, although the highest prevalence of vulnerability is observed in rural areas of Class 5.

Out of the 2.1 million vulnerable people living in Ecuadorian mountain areas, 1 million belong to households benefiting from some form of social safety nets.3 This leaves about 1.1 million mountain people who are vulnerable to food insecurity and do not benefit from any social safety nets, corresponding to 16 percent of total mountain population.

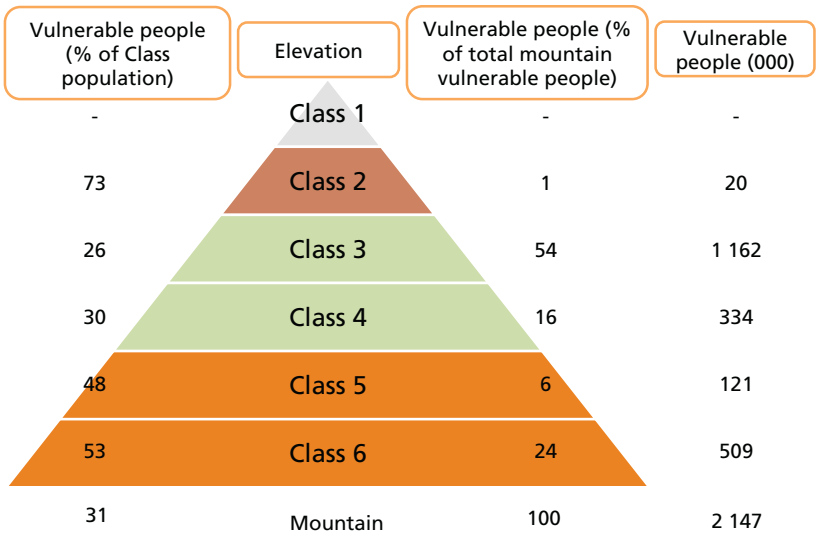


Figure 19. Ecuadorean mountain people vulnerable to food insecurity by elevation class in 2012 (in green the classes with the lower share of vulnerable people to total class population; in red the class with the highest prevalence).

3 Free breakfast and lunch at school, "Mi papilla", food bags, visits by a health care team, etc.

Malawi

Figure 20. Mountain areas of Malawi (CDE, University of Berne)

Malawi, a landlocked country in eastern Africa, experienced fast population growth over recent years, becoming one of the most densely populated countries in sub-Saharan Africa. In 2014, the country had a GDP of US$4.3 billion and an estimated population of 16.8 million, and was therefore classified by the World Bank as a "low-income" country. According to SOFI 2015, 21 percent of the population was undernourished in the period 2010-11.

Malawi's main territorial features are the East African Rift – part of the Great Rift Valley – which runs through the country from north to south, and Lake Malawi, which covers 20 percent of the country's surface area. Elevated plateaus are located west of the Rift Valley and south of Lake Malawi, while southernmost regions are characterized by very low elevations and hot climate. The rainy season begins in November and ends in April, while from May to October there is almost no rainfall.

Around 31 percent of the Malawian population[4] live in mountain areas, almost entirely located at elevations lower than 1 500 m. Three out of Malawi's four main cities are partially located in elevation Class 5, the class with the largest mountain population.[5] Almost two-thirds of the total population live in elevated plains and plateaus that cannot be classified as "mountain" as they miss the slope requisite; about 85 percent of total Malawian population, finally, lives in rural areas.

The Third Integrated Household Survey (IHS3), undertaken from March 2010 to March 2011, provides a rich source of information on Malawian household livelihoods. Its data on household elevation, slope and terrain roughness, enable the allocation of each surveyed household to the respective elevation class.

About half the total Malawian population lives below the poverty line, and about 24 percent of the population lives below the ultra-poor (food) poverty line. The share of the ultra-poor on total population is lower in the relatively more urbanized elevation Class 5, where higher educational levels are also attained. Elevation Class 4 – the highest inhabited class in Malawi – is instead the class with the lowest level of per capita consumption, the higher share of rural population and the greater average distance from main roads.

4 For the case study of Malawi, the IHS3 survey weights have been used in order to expand the results to the population. Total population is referred to the Mid-Point of IHS3 Data Collection (September 2010).

5 Namely Blantyre City (South), Zomba (South) and Mzuzu (North). The other main city is Lilongwe, the Malawian capital, located in the Central region, on mid-altitude plateaus and high altitude plains.

At national level, only 8 percent of total population has piped water as its main source of drinking water; more than half of the population relies on boreholes for drinking water, with an average time spent to get drinking water of about 15 minutes. While in urban areas the percentage increases to 38 percent, only 2 percent of people in rural areas has access to piped drinking water, with consequences on the average time spent to collect water[6]. In addition, only 7 percent of Malawi's total population has access to flush toilets and Ventilated Improved Pit (VIP) latrines, with better conditions – on average – in Class 5.

Malawi (©Flickr/IamNotUnique)

Around 20 percent of the working age population, some 1.3 million people, declared not to have worked over the week preceding the interview, nor to have an economic or farming activity. As opposed to the above mentioned indicators, however, unemployment is higher in urban (36 percent) than in rural (15 percent) areas. Almost 60 percent of the working age population undertakes agricultural or fishing activities, while another 13 percent is involved in informal off-farm (or ganyu) labour. The most cultivated annual crop is maize, followed by tobacco and groundnuts. Maize, indeed, is a major factor in Malawian food security. Tobacco, cotton and oilseeds, on the other hand, are the main cash crops. At higher elevations, beans and soybean are the most cultivated crops after maize. Malawian agriculture, however, is almost entirely rain fed and, hence, subject to the seasonal succession of rainy and dry seasons.

The share of food consumption over total consumption is as high as 87 percent, with no significant differences between mountain and non-mountain areas. About half of the dietary energy is derived from the food groups "cereals" and "roots and tubers" (Table 21). Fish and pulses are fundamental components of the Malawian diet as well, as they provide about half of total dietary proteins, with fish more important than pulses at lower elevations and vice versa.

Almost half of the Malawian population in the 12 months preceding the interview had faced a situation in which not enough food was available for the household, with very high portion of the population affected by food scarcity in the central months of the 2009/10 rainy season. The main causes of the food shortages mentioned by respondents in rural areas were all related to scarce availability of food stocks, due to either lack of farm inputs, drought/poor rains, or small land size. In urban contexts, high prices in the food market were the main cause of the inadequacy of food access. This food security pattern did not show substantial differences between mountain and non-mountain areas.

About two-thirds of the Malawian mountain population was estimated to be vulnerable to food insecurity in 2011–12, corresponding to 2.8 million people, with physical access being the main food security dimension contributing to the final figure. The majority of vulnerable people live in rural areas, where they represent almost 80 percent of rural mountain population, while the prevalence of vulnerability in urban areas is 22 percent (Table 21). Food insecurity in rural areas is mainly driven by the small farm size and absence of irrigation systems as these do not support sufficient accumulation of food stocks that will suffice to last over both the dry season and the pre-harvest period. In urban contexts, high unemployment and poverty rates, associated with a very high Engel's ratio (the portion of income spent on food) and strong seasonal food price fluctuations, are its main drivers.

6 7 minutes in urban areas vs 16 minutes in rural areas.

Elevation	Vulnerable people (%)	Vulnerable people ('000)	Vulnerable people (%)	Vulnerable people ('000)
Class 4 (1 500–2 500) (slope 2%)	83	224	Urban: 36 Rural: 86	Urban: 6 Rural: 218
Class 5 (1 000–1 500) (slope 5%)	55	1 247	Urban: 20 Rural: 74	Urban: 152 Rural: 1 095
Class 6 (300–1 000) (slope 5%)	75	1 364	Urban: 28 Rural: 82	Urban: 70 Rural: 1 295
Total Mountain areas	65	2 835	Urban: 22 Rural: 79	Urban: 227 Rural: 2 608
Class 0 (0-300)	76	7 464	Urban: 42 Rural: 81	Urban: 477 Rural: 6 988
Malawi	**73**	**10 300**	**Urban: 32 Rural: 80**	**Urban: 704 Rural: 9 596**

Table 21. Vulnerable people by elevation class in Malawi estimated through the Composite Vulnerability Indicator (CVI)

Source: Author's elaborations based on IHS3 data.

Social safety nets reach almost 20 percent of vulnerable mountain people through, among other things, school feeding programmes, distribution of free food, food for work and cash for work programmes, targeted nutrition programmes, and direct cash transfers. Expanding the results by using the survey weights indicates that almost 2 million of the 10.3 million vulnerable people in Malawi benefit from social safety nets.

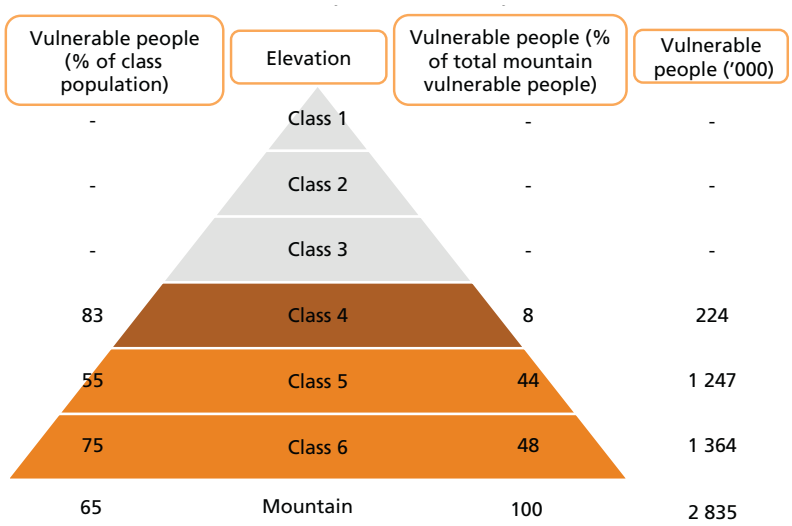


Figure 21. Malawian mountain people vulnerable to food insecurity by elevation class in 2010/2011

Malawian woman walking with her child
(©Flickr/Skip Russel)

The relationship between metabolism, altitude and temperature

The effects of altitude on the energy requirements of long-term mountain dwellers are extremely unclear and research findings are often inconsistent. While differences between the energy requirements of highland and lowland people may be observed, this is usually associated more with temperature rather than altitude.

Altitude is not usually thought to affect mountain residents, as it has only short-term effects that tend to disappear after a few weeks. Sudden exposure of lowland people to high altitudes, especially above 3 500 m, leads to reduced food consumption and weight loss. However, these are temporary effects and, for example, appetite returns to normal within two weeks of high altitude residency.

Since the first FAO and WHO Expert Consultations on Human Energy Requirements in the 1950s, considerable studies have been carried out on the effect of temperature and humidity changes on human energy requirements. The FAO "reference man" is 25 years of age, weighs 65 kg and lives in a temperate zone at a mean annual temperature of 10°C. His energy requirements should increase 3 percent for every 10 °C of mean annual temperature below the reference temperature of 10 °C, as cold and exercise are responsible for an increase in human energy requirements.

The effect of altitude depends on acclimatization. As a result, the impact of altitude on the metabolism of mountain people is not easy to quantify, and no generalized adjustments can be recommended. Yet, elevation, slope and temperature do affect the productivity of the soils and their nutrient supply and, thus, the nutrient properties of harvested food. As a consequence, mountain people have adapted over the centuries and developed unique metabolic processes.

Metabolic processes in populations living at high altitudes

Paola Virginia Gigliotti and Francesco Coscia, Laboratory of Physiology of Sport, University of Perugia

People who are born and raised in villages at high elevations, up to about 5 100 m, have adapted to the altitudes over generations. They are genetically able to carry out normal daily activities in conditions that would not be amenable to the health of lowland people.

The environmental characteristics of mountains – namely dry air, low temperatures and reduced oxygen pressure – are key factors to human adaptation to life in mountains. In fact, the genetic adaptation patterns of the two "highest" populations of the world, the Tibetans and the Andeans, cannot be found in any other populations.

Adaptation to mountainous environments means the optimization of oxygen use under the conditions of chronic hypoxia (low levels of blood oxygen). Oxygen is used in metabolic processes, both to maintain the basal metabolic rate and body temperature and for the oxidation reactions of the energy substrates that are needed for physical activity.

Hypoxia also affects protein synthesis and thus the maintenance of muscle mass. Protein synthesis at high elevation is, in fact, reduced by the action of hypoxia on enzymes. This results in a need for meat and milk proteins, enzymes from various vitamins, and amino acids such as arginine, the substrate that allows for the synthesis of nitric oxide. Nitric oxide acts on vascular walls, causing decreases in peripheral resistance and thus vasodilation, better tissue oxygenation and a decrease in blood pressure. An increase in blood pressure in the pulmonary artery, on the contrary, would lead to pulmonary edema.

Tibetans who live at high altitudes have a greater amount of nitric oxide in their muscle tissue than other mountain populations. They have less mitochondria than usually required for normal activities, and they remain very active.

All the metabolic activities described above require catalysts, *i.e.* vitamins, for the redox (oxidation-reduction) reactions of the energy substrates (proteins, fatty acids, carbohydrates). People living at high altitudes practice mainly aerobic activities. This helps to optimize the exchange of oxygen for the tissues and lungs. Aerobic activity can use substrates glucose, fatty acids and amino acids as energy, the latter also being essential to maintain protein mass.

Fatty acids have higher energetic potential than an equal amount of glucose. During a maximal exercise performed at high altitude by local mountain people – people chronically exposed to hypoxia – lactate concentration progressively decreases. This phenomenon is known as "lactate paradox".

Altitude usually increases oxidative stress with related substance degradation. However, the Tibetan populations have proven to be an exception. Their muscles show low accumulation of lipofuscin, a substance that reflects the damage caused by free radicals to the body cellular structures, and a significant increase in protein with high antioxidant action. This feature is only present in the native Tibetan populations, living at altitudes up to 4 800 m. Tibetans also have a higher concentration of nitric oxide.

While Tibetans adapted by developing these genetic protection factors, this is not the case for other populations, such as those living in the Andes. Their adaptation happens through ventilation mechanisms and through an increase in hemoglobin concentration and oxygen transportation.

Tibetan women during pregnancy have an increased blood flow to the placenta due to the protective effect of nitric oxide. Andean women's bodies ensure oxygenation to the fetus through an increase of hemoglobin concentration and ventilation.

These scientific observations are consistent with the centuries-old history of survival of these populations, which is directly linked to the history of their agricultural and livestock production. Agricultural production in Tibet has always been based on a combination of agriculture, especially wheat and barley, as they are very resistant to cold, and animal husbandry. Their pastoralism activities include yak, sheep and Tibetan goat breeding. The yaks provide abundant milk and meat.

Tibetan monasteries and, in more recent times, small Tibetan schools have ensured protein availability with their small herds. Tea with yak butter is in fact the national drink of Tibet.

Historically, Andean peoples have always had a diet comprising corn, potatoes, tubers and a special meat, the "*cuy*" (guinea pig), which is high in protein and low in fat, plus river fish. In the pre-Columbian era, the central Peruvian Andes were the largest cultivation centre of the ancient world for grasses, legumes, many types of fruit and aromatic herbs.

Both scientific and historical anthropological studies have supported the assumption that for populations living at high altitudes, food quality is more important than food quantity. Unfortunately, migration and "food globalization" often meet the quantitative but not the qualitative criterion.

Mongolian Farmers Work in Fruit Seeds Project
(©UN Photo/Eskinder Debebe)

4

Conclusions and way forward

Potato for nutrition and for business in Lushoto, Tanzania (@FAO/Sara Quinn)

Conclusions and way forward

Farmers waiting for transportation on the side of the road in Taipicha, near Turpo, Peru. (©IFAD/Pablo Corral Vega)

This study was undertaken to increase understanding of the current vulnerability to food insecurity of mountain peoples living in developing countries and to quantify the changes. It found that during the period 2000–2012, the situation of rural mountain people deteriorated, and their vulnerability increased almost everywhere. The results are alarming: mountain peoples are among the world's poorest and hungriest, and a shocking 45 percent of rural mountain peoples are food insecure. In other words, about one in three mountain people in developing countries is at risk of hunger, compared with an average of one out of eight at global level.

The lack of food security combined with widespread poverty, political, social and economic marginalization, limited access to education, health and sanitation services and the hardship of living in a hostile environment, combined with the effects of climate change, is heavily affecting the livelihoods of mountain populations and their capacities to exploit their full potential.

This has also resulted in a strong depopulation in the highest mountain areas in which these difficulties are more severe, forcing many mountain peoples to leave their homes in search of a better future. Indeed, the study found that during the period 2000–2012, the population steadily decreased in Class 1, the highest mountain class (elevation ≥ 4 500 m), and grew much more slowly than the global average in Class 2 (elevation 3 500–4 500 m).

The results of this study are a clear call to politicians, development agencies and experts. Mountains urgently need attention, investments, social protection policies and interventions to support their sustainable development and economic growth. According to the latest Intergovernmental Panel on Climate Change (IPCC) report, temperatures are predicted to increase further in most mountain areas, making it very likely that in the near future, disasters and extreme events will impact mountains even more. At this rate, climate change could increase the vulnerability of mountain peoples in the long run and may push them to continue to outmigrate or to deplete mountain natural resources to survive.

A collective effort is urgently required to ensure that mountain ecosystems are preserved and the livelihoods of mountain peoples improved to match the standard of lowland peoples. When some groups of inhabitants within a given country or region face harsher conditions than others, this may lead to a high level of inequality, and to social and political instability. As the vulnerability of mountain populations grows, migration increases, with migrants moving towards urban centres that often already face high population pressure.

In mountain areas, where family farming and smallholder agriculture, forestry and animal husbandry are the prevailing farming systems, it is key to create a supportive, enabling institutional and political situation in which mountain peoples can have access to key services such as training, information, credit and healthcare, and benefit from supportive political systems and proper infrastructure.

Markets are often difficult to reach from mountain villages due to the distance, extreme climatic events, lack of roads and other obstacles. Small producers could benefit from specific training to improve the entire production chain of their main products by, for example, creating cooperatives and similar forms of collaboration to reduce the number of middlemen in order to obtain a fair compensation for their products.

Equitable economic growth is central to the fight against hunger and malnutrition – countries that become richer are less likely to be food insecure. However, for mountain peoples, the key factor is inclusive growth, meaning growth that promotes access for everyone to food, assets and resources, particularly for poor people and women so they can develop their potential. National averages can be misleading in countries with low economic cohesion (*i.e.* strong income disparity). Policy-makers as well as the general public could incorrectly assume that the vulnerability to food insecurity is low, while in mountain areas and in other marginal areas, the vulnerability could be high or increasing.

Because the necessary disaggregated data does not exist that would give a specific picture of the vulnerability of indigenous mountain communities, conservative estimates have had to be made based on more general data. Thus, it is very likely, that the vulnerability of these communities is even higher than identified in this study.

Mountain agriculture has significant potential to contribute to improving food security. Investments and technical support are needed to diversify and boost mountain production systems through, for example, integrating indigenous knowledge and traditions with modern techniques. Realizing this potential calls for enhanced dialogue concerning key resource management issues and ecosystem services between mountain people and lowlanders.

Good governance systems with robust participation and ownership of mountain communities as well as secure land tenure are crucial driving factors for promoting inclusive growth. This is particularly relevant to mountain areas which are not only geographically isolated, they are also often politically and socially marginalized.

This study is a call to action. Strong political commitment and effective actions are necessary to invert the hunger trend and address the roots of food insecurity in mountains, filling the hunger gap between lowland and upland people, and ensuring that mountains can continue supporting life on Earth.

Annex – Country grouping scheme

Geographical region and composition of each region	
Africa	
Eastern Africa	
Burundi	Mozambique
Comoros	Réunion
Djibouti	Rwanda
Eritrea	Seychelles
Ethiopia	Somalia
Kenya	South Sudan
Madagascar	Uganda
Malawi	United Republic of Tanzania
Mauritius	Zambia
Mayotte	Zimbabwe
Middle Africa	
Angola	Democratic Republic of the Congo
Cameroon	Equatorial Guinea
Central African Republic	Gabon
Chad	Sao Tome and Principe
Congo	
Northern Africa	
Algeria	Sudan
Egypt	Tunisia
Libya	Western Sahara
Morocco	
Southern Africa	
Botswana	South Africa
Lesotho	Swaziland
Namibia	
Western Africa	
Benin	Mali
Burkina Faso	Mauritania
Cabo Verde	Niger
Cote d'Ivoire	Nigeria
Gambia	Saint Helena
Ghana	Senegal
Guinea	Sierra Leone
Guinea-Bissau	Togo
Liberia	
Americas	
Latin America and the Caribbean	
Caribbean	
Anguilla	Haiti
Antigua and Barbuda	Jamaica
Aruba	Martinique
Bahamas	Montserrat
Barbados	Puerto Rico

Bonaire, Saint Eustatius and Saba	Saint-Barthélemy
British Virgin Islands	Saint Kitts and Nevis
Cayman Islands	Saint Lucia
Cuba	Saint Martin (French part)
Curaçao	Saint Vincent and the Grenadines
Dominica	Sint Maarten (Dutch part)
Dominican Republic	Trinidad and Tobago
Grenada	Turks and Caicos Islands
Guadeloupe	United States Virgin Islands
Central America	
Belize	Honduras
Costa Rica	Mexico
El Salvador	Nicaragua
Guatemala	Panama
South America	
Argentina	French Guiana
Bolivia (Plurinational State of)	Guyana
Brazil	Paraguay
Chile	Peru
Colombia	Suriname
Ecuador	Uruguay
Falkland Islands (Malvinas)	Venezuela (Bolivarian Republic of)
Northern America	
Bermuda	Saint Pierre and Miquelon
Canada	United States of America
Greenland	
Asia	
Central Asia	
Kazakhstan	Turkmenistan
Kyrgyzstan	Uzbekistan
Tajikistan	
Eastern Asia	
China	Japan
China, Hong Kong Special Administrative Region	Mongolia
China, Macao Special Administrative Region	Republic of Korea
Democratic People's Republic of Korea	
Southern Asia	
Afghanistan	Maldives
Bangladesh	Nepal
Bhutan	Pakistan
India	Sri Lanka
Iran (Islamic Republic of)	
South-Eastern Asia	
Brunei Darussalam	Philippines
Cambodia	Singapore
Indonesia	Thailand
Lao People's Democratic Republic	Timor-Leste
Malaysia	Viet Nam
Myanmar	
Western Asia	
Armenia	Lebanon
Azerbaijan	Oman
Bahrain	Qatar

Cyprus	Saudi Arabia
Georgia	State of Palestine
Iraq	Syrian Arab Republic
Israel	Turkey
Jordan	United Arab Emirates
Kuwait	Yemen
Europe	
Eastern Europe	
Belarus	Republic of Moldova
Bulgaria	Romania
Czech Republic	Russian Federation
Hungary	Slovakia
Poland	Ukraine
Northern Europe	
Åland Islands	Isle of Man
Channel Islands	Jersey
Denmark	Latvia
Estonia	Lithuania
Faeroe Islands	Norway
Finland	Sark
Guernsey	Svalbard and Jan Mayen Islands
Iceland	Sweden
Ireland	United Kingdom of Great Britain and Northern Ireland
Southern Europe	
Albania	Malta
Andorra	Montenegro
Bosnia and Herzegovina	Portugal
Croatia	San Marino
Gibraltar	Serbia
Greece	Slovenia
Holy See	Spain
Italy	The Former Yugoslav Republic of Macedonia
Western Europe	
Austria	Luxembourg
Belgium	Monaco
France	Netherlands
Germany	Switzerland
Liechtenstein	
Oceania	
Australia and New Zealand	
Australia	Norfolk Island
New Zealand	
Melanesia	
Fiji	Solomon Islands
New Caledonia	Vanuatu
Papua New Guinea	
Micronesia	
Guam	Nauru
Kiribati	Northern Mariana Islands
Marshall Islands	Palau
Micronesia (Federated States of)	

Polynesia	
American Samoa	Samoa
Cook Islands	Tokelau
French Polynesia	Tonga
Niue	Tuvalu
Pitcairn	Wallis and Futuna Islands

There is no established convention for the designation of "developed" and "developing" countries or areas in the United Nations system. In common practice, Japan in Asia, Canada and the United States in northern America, Australia and New Zealand in Oceania, and Europe are considered "developed" regions or areas.

Developed and developing regions	
Developing regions	
Africa	Asia excluding Japan
Americas excluding Northern America	Oceania excluding Australia and New Zealand
Developed regions	
Northern America	Japan
Europe	Australia and New Zealand

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For millions of people living in mountainous areas, hunger and the threat of hunger are nothing new. Harsh climates and the difficult, often inaccessible terrain, combined with political and social marginality make mountain peoples vulnerable to food shortages.

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This study presents an updated geographic and demographic picture of the world's mountain areas and assesses the vulnerability to food insecurity of mountain dwellers in developing countries, based on a specially designed model. The final section presents an alternative and complementary approach to assessing hunger by analyzing household surveys.

The results show that the living conditions of mountain dwellers have continued to deteriorate in the last decade. Global progress and living standard improvements do not appear to have made their way up the mountains and many mountain communities lag way behind the full eradication of poverty and hunger.

This publication gives voice to the plight of mountain people and sends a message to policy-makers on the importance of including mountain development in their agendas as well as specific measures and investments that could break the cycle of poverty and hunger of mountain communities and slow outmigration from mountain areas.

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