The Last Straw

Food security in the Hindu Kush Himalayas and the additional burden of climate change

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Food security in the Hindu Kush Himalayas and the additional burden of climate change

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Summary

Climate change and increasing global food prices have accentuated the question of whether there will be enough food in the future to feed a growing world population. The latest contributions to the Intergovernmental Panel on Climate Change (IPCC) Fifth Assessment Report identify food insecurity as one of the key risks of climate change, potentially affecting all aspects of food security. Climate-related disasters (e.g., floods, droughts and storms) are among the main drivers of food insecurity and markets have shown themselves to be very sensitive to recent extremes in climate.

Food insecurity is already a fact of life in the Hindu Kush Himalayas (HKH), where the harsh climate, rough terrain, poor soils, and short growing seasons often lead to low agricultural productivity and food deficits. While most people have access to agricultural land, farming is carried out on comparatively small parcels of land ranging from 0.23–0.83 ha per household. As a so-called climate change hotspot, climate change and extreme weather events like floods and droughts are projected to impact food security in mountain regions like the HKH particularly hard. The effects of climate change are compounded here due to particular mountain characteristics: high levels of poverty and high proportions of undernourished people, high dependence on local agricultural productivity and depleted natural resources, vulnerable supply lines and complicated logistics to external markets, and poor infrastructure.

The semi-subsistence farming systems of the HKH use a high diversity of agricultural practices and historically, they have been quite adept at using the inherent flexibility of mountain food systems. But now farmers are struggling to maintain food security in the context of climate change and environmental degradation. Recent vulnerability assessments show that over 40% of households in the mountainous region of the HKH are facing decreasing yields in their five most important crops as a result of floods, droughts, frost, hail, and disease. As a result, many farmers are changing farming practices, including delayed sowing and harvesting, resowing, changing crop varieties, and abandoning staple crops and livestock varieties.

Another response to change includes greater involvement with cash crop production. While this potentially opens new opportunities for income generation, it also leaves farmers open to swings in markets. These new production patterns are also creating problems related to improper soil and water management, and the lower diversity in production is leading to less diverse diets and more vulnerable food security. In addition, cash crops, like staple crops, are also being threatened by the impacts of climate change.

The status of food security varies greatly across the mountains of the HKH region. While the number of undernourished people globally has been declining over the last two decades, the change has been disproportionately slower in the HKH countries and undernourishment remains high in the region. The mountain areas of these countries show the highest degree of food insufficiency and persistent undernourishment remains an urgent situation.

Outmigration is one of the greatest social challenges to farming in the HKH. The number of households engaged in off-farm employment ranges from 13% in Pakistan to 57% in Nepal. While it is a source of social and financial remittances for many households, it also results in frequent labour shortages on farms. Remittances are usually not enough to compensate for the missing work force. Because migration is also a highly engendered process, increasingly it is women and the elderly

who are left to tend the farms. As farming becomes more feminized, it brings challenges for the entire household. Women tend to be disproportionately affected by climate change and disasters because they lack access to information and resources, and are limited in their mobility and capacity to participate in decision-making.

Widespread poverty through the mountain communities of the HKH continues to be a major factor in food insecurity here. As women are left to tend farms on their own, it affects both the time and knowledge they have to properly care for their children, including breastfeeding. Many children are affected by malnutrition, and the rate of stunting is high across much of the region, with the highest figures in remote mountain areas. Women also suffer from higher levels of malnutrition as a result of the higher energy demands placed on them in conjunction with limited food availability.

Climate change is projected to affect food security in a number of ways. Scenarios indicate that the Himalayan glaciers will release more water in the next 10–20 years, followed by a gradual decrease in most major river basins. However, there will be significant variations in this pattern across the region and future water supply will be less predictable. While the Himalayan water towers will discharge less water over time, rainfall will increase. Conditions for food production and livelihoods in general will depend greatly on the balance through the seasons between glacial melting and rainfall. Most projections suggest that more extreme weather events and increasing rainfall variability will lower agricultural productivity.

Climate change impacts on food security will vary across the HKH. Pronounced trends in the HKH indicate warming and drought-proneness in China and the Koshi basin, increased winter water stress in South Asia, high variability in monsoon and flood-related disasters in the Upper Indus and plains of other basins, and warming in higher altitudes in all basins. All these trends present a high risk to agriculture. The extensive decrease expected in storage capacity will affect water supplies for agriculture, hydropower potential, and other uses.

Food insecurity has the greatest impact on those people in the HKH region who are socially, culturally, economically, or otherwise marginalized, in effect a majority of the mountain dwellers. Achieving improved food security in the face of climate change will require:

- Filling in knowledge gaps about food production systems
- Targeting and increasing involvement of younger generations in farming
- Supporting greater diversity in small-scale farming
- Developing more gender-sensitive farming approaches
- Strengthening education and building effective networks for knowledge sharing
- Integrating food security development goals in policies addressing climate change adaptation
- Mainstreaming mountain-related issues into the current discussions on the Post-2015 process and Sustainable Development Goals.

1 2 3 4 5

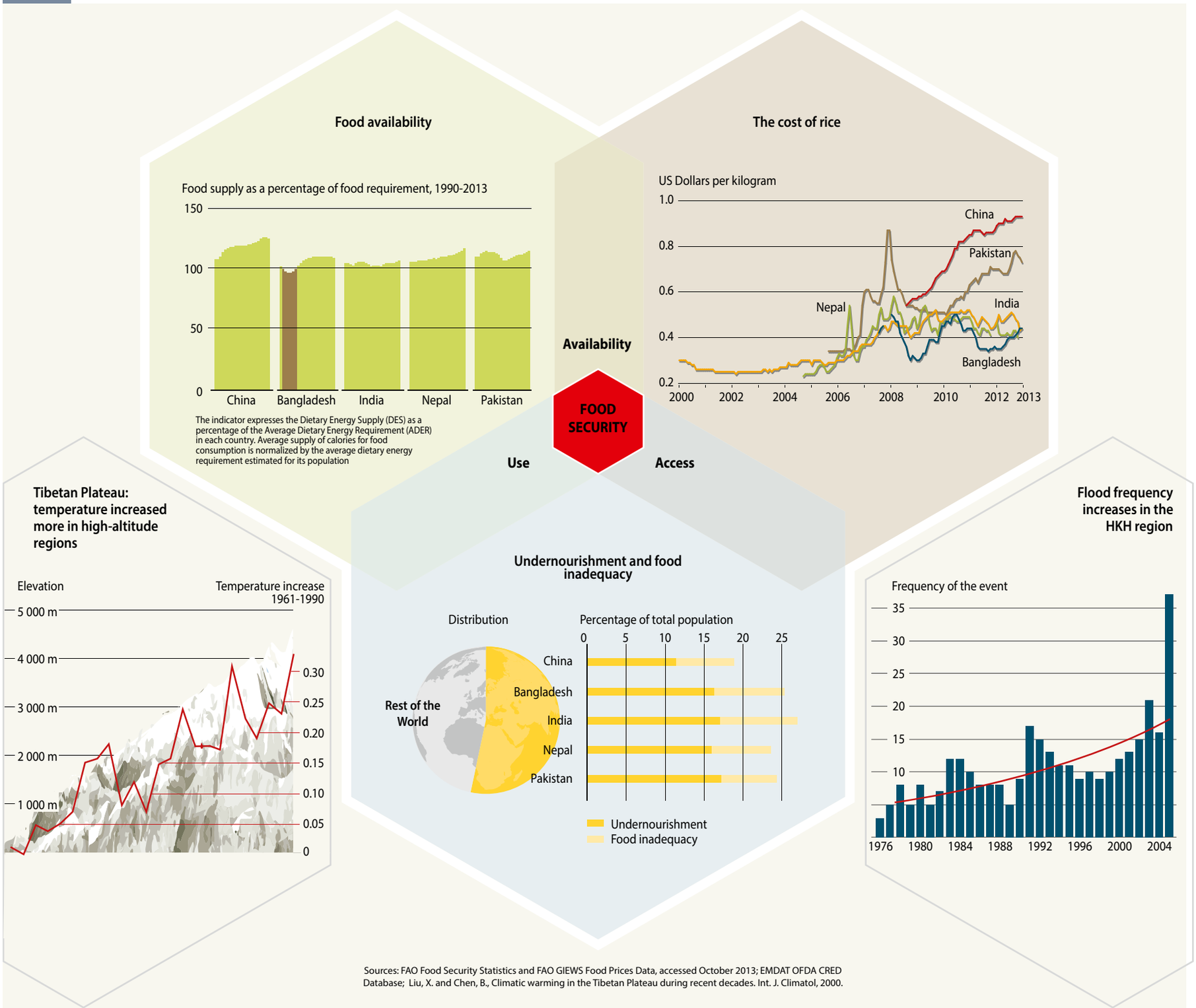
Mountain outposts are more vulnerable to change

- Climate change will have greater impacts on food security than previously expected
- Mountain regions are hit harder than lowlands
- Food security in the mountains is increasingly exposed to global market forces

"Ten years ago, all of our families had livestock with a few milk cows, pigs, and goats each, but now the families can only manage to raise some pigs. Due to the drought, there is insufficient fodder growth around the village to support cows, and only three families keep goats now (about 20 goats per family). Similarly, from a village crop production of rain-fed potatoes, wheat, and maize 10 years ago, now only potatoes can be grown in the dry conditions. However, potato production is still meager and only provides a subsistence crop. The forested slopes on the village mountain have traditionally been a reliable source of medicinal plants and forest food. Medicinal plants are especially valuable as they provide a good cash income when sold at the market but due to a growing need by villagers for these during the droughts, the forest's resources are overexploited with no medicinal plants now. Life is very hard for Qi Ping people these days."

■ *Village headman in Qi Ping village, Yunnan, China*

FIGURE 1



Sources: FAO Food Security Statistics and FAO GIEWS Food Prices Data, accessed October 2013; EMDAT OFDA CRED Database; Liu, X. and Chen, B., Climatic warming in the Tibetan Plateau during recent decades. Int. J. Climatol, 2000.

"Food security 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."[2]

■ *Rome Declaration on World Food Security, 1996[3]*

The situation in Qi Ping is not unusual for the mountainous regions of the Hindu Kush Himalayas (HKH).[1] In this harsh and rugged region, food insecurity is common and vulnerability is a fact of life. In recent years, however, food security has worsened globally, and in the coming decades climate change is expected to affect food production particularly hard. For vulnerable mountain communities like Qi Ping and others like it, greater climate variability, erratic precipitation patterns, and extreme weather events associated with climate change will only serve to exacerbate an already marginal existence.

Food security stands at the intersection of economic impacts and ecological impacts (Figure 1). In our increasingly globalized world, no region is immune to the effects of international market forces, be it for food, energy, or finance. Likewise, the impacts of climate change are being felt across all regions of the world, with food insecurity identified as one of the key risks (IPCC 2014b). But while these influences are global, the extent of effects are regional and unequal. How well different societies can cope with and adapt to rapid change is as much a factor of their development as it is of their geography.

Food security in the mountain communities of the Hindu Kush Himalayas depends primarily on local production and household purchasing power (Tiwari and Joshi 2012). They are highly dependent on their local natural resources and subsistence production for food. Like many agrarian mountain societies, however, the HKH is characterized by high levels of poverty which have a direct impact on their ability to both produce and acquire food (Section 3.2). A regional level poverty study in the Hindu Kush Himalayas revealed that of the 200 million people living in the region, an estimated 61 million, or 31% of the population, live below the poverty line (excluding China and Myanmar)[4] (Hunzai *et al*. 2011). While poverty may be higher in certain pockets of the plains, the issues are more complex in the mountains. Food security in the mountains is already challenged by a fragile environment, depleted natural resource systems, limited availability of suitable land for large-scale production, physical inaccessibility, and poor local infrastructure. When combined with poverty, people are left with very limited options to cope with change and the food security situation can become dire. In many parts of the HKH, the result is high rates of malnutrition, and nutritional security that is threatened by poor diets, hard physical labour, and poor sanitary conditions (Dutta and Pant 2003).

The drive to improve their lives has seen mountain societies move increasingly from subsistence farming to market-based agricultural production and cash crops, becoming more integrated into regional and global markets (ICIMOD 2008; Pingali 2006; Rasul and Thapa 2003). While this can provide new opportunities for income generation, it also leaves communities vulnerable to swings in world markets. World food prices have risen sharply in recent years and markets have become more volatile as a result of increased demand for grains for food, feed, and biofuels; increased economic growth; reduced global stocks and storage capacities; low investment in agriculture; high energy prices; and adverse weather events around the world (Section 3.1).

In addition to rising food costs, the world's food supply has failed to keep pace with the increased demand driven by economic and population growth (FAO *et al.* 2013). While the demand for cereals has risen steadily, world cereal production has leveled out and since 2000, the global consumption of cereals has been higher than production (ICIMOD 2008). The shortfall has largely been covered by reducing global grain reserves which can now support global consumption for a much shorter period of time. This is not a sustainable solution over the longer term and it is poorer countries who will feel the effects first.

At the country level in the HKH, food grain production managed to keep pace with or exceed population growth up until the 1990s. Since that time, however, production has remained more or less constant while the population has continued to grow, resulting in food deficiencies (Rasul 2010). In the mountainous

1. The Hindu Kush Himalayan region extends over all or part of eight countries: Afghanistan, Bangladesh, Bhutan, China, India, Myanmar, Nepal, and Pakistan.
2. Food security is usually defined along four dimensions; availability, accessibility, use, and system stability.
3. www.fao.org/docrep/003/w3613e/w3613e00.htm
4. Information on the population living below poverty line is not available for China or Myanmar so the real figure may be higher.

The boundaries and names shown and the designations used on this map do not imply official endorsement or acceptance by ICIMOD, CICERO or GRID-Arendal

"People who are socially, economically, culturally, politically, institutionally, or otherwise marginalized are especially vulnerable to climate change."

■ *IPCC Fifth Assessment Report (2014b)*

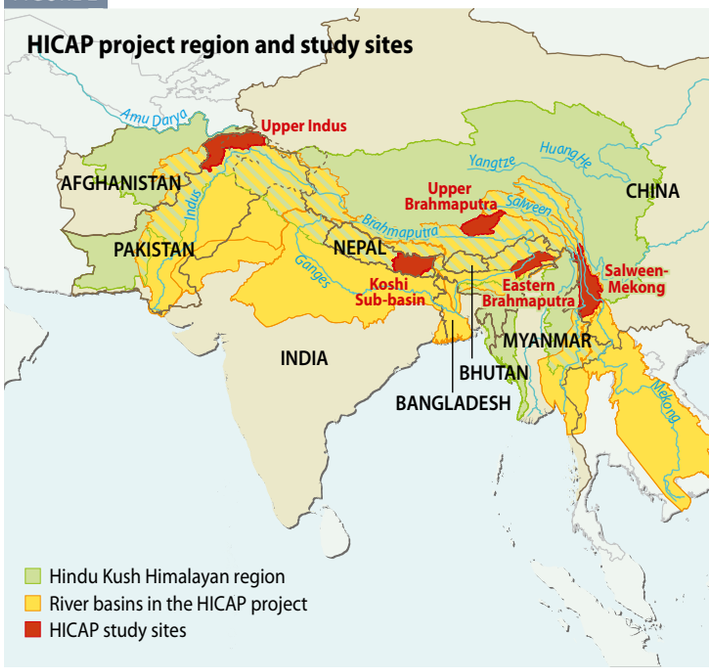
regions of the HKH, where food production has always been less than demand, declining production is exacerbating the situation.

Compounding the socio-economic and existing environmental stressors in the HKH are the growing impacts of climate change (Section 4). The recent Fifth Assessment Report (AR5) of the Intergovernmental Panel on Climate Change (IPCC) notes that all aspects of food security will be potentially affected by climate change (Porter *et al.* 2014). For mountain societies, a changing climate means more variability and less predictability in seasons and weather patterns so critical to agriculture. Some areas already experience more frequent flooding, including flash floods, while others are becoming more drought-prone and water-stressed (see Section 4.2). Farmers need to adapt to these changes but without seriously impacting environmental sustainability. Lacking proper knowledge and in the absence of sound policies, there is a great danger that already vulnerable mountain communities will continue to exercise maladaptive strategies such as overgrazing, deforestation, cultivation of inappropriate crops, and unsustainable water use. Over the long term, the result is even lowered resilience to change in livelihoods and food systems.

The Hindu Kush Himalayas has extremely varied social and ecological environments, and oftentimes the mountain regions of these countries have more in common with each other than with other parts of their own countries. Despite facing similar challenges, however, there is often a lack of regional perspective on common issues. To better understand the changes facing the Hindu Kush Himalayan region, the International Centre for Integrated Mountain Development (ICIMOD), the Center for International Climate and Environmental Research – Oslo (CICERO), and GRID-Arendal established the Himalayan Climate Change Adaptation Programme (HICAP). HICAP aims to enhance the resilience of mountain communities through improved understanding of vulnerabilities, opportunities, and potentials for adaptation.

As part of HICAP, this report provides a regional overview of food security in the mountains of the HKH under changing environmental and socio-economic conditions, and presents options to improve policy, actions, and knowledge to help improve food security in the region. The unique information gathered from HICAP study sites in the Upper Indus, Koshi, Upper Brahmaputra, Eastern Brahmaputra, and Salween-Mekong river basins is used throughout this report to help illustrate the food security situation on the ground (Figure 2).[5]

FIGURE 2



5. This study uses data from the 2013 Poverty and Vulnerability Assessment (PVA) carried out by ICIMOD and partners under HICAP. This large-scale quantitative assessment covers over 8,000 households and was conducted in four countries in the Hindu Kush Himalayas to assess vulnerability in households and communities in the region. The assessment addresses major research gaps on livelihood vulnerability, adaptive capacity, and responses to climate change.

"Remaining food secure is the major goal of most rural households even today."

■ *Maharjan 2010*

1 2 3 4 5

Agriculture and food security in the Hindu Kush Himalayas

- Food security is highly determined by local agricultural productivity and purchasing power
- Climate change is testing the resilience of farming systems
- Mountain households face declines of key food crops

FIGURE 3

Land and population in the Hindu Kush-Himalaya region

Source: Rasul and Kollmair, 2011, based on Pratap, 2001

2.1 **Farming systems rely on diversity**

Diversity has always been central to farming systems in the challenging environment of the Hindu Kush Himalayan mountains. A generally harsh climate, rough and sloping terrain which needs to be terraced, poor soils, and short growing seasons characterized by low temperatures and reduced plant growth often lead to low agricultural productivity and food deficits (Figure 3). Farms here are labour intensive, low input systems of low productivity. Mountain farmers grow field crops and trees, keep livestock, and collect non-timber forest products, as well as engage in off-farm activities such as labour, petty trade, tourism, and other services to ensure livelihood security. The majority of households collect their own seeds for cultivation, use only an ox or buffalo for ploughing, and use manure and compost in the fields. While most of the HICAP sample populations in the Upper Indus, Koshi, Eastern Brahmaputra, and Salween-Mekong sub-basins have access to agricultural land, farming is carried out on comparatively small parcels of

land ranging from 0.23 ha per household in the Upper Indus sub-basin of Pakistan to 0.83 ha per household in the Eastern Brahmaputra sub-basin of India (Figure 4) (HICAP PVA). The small and fragmented nature of agricultural plots in this region limits the use of improved farming technologies.

Mixed farming systems are the norm in the HKH region where a small variety of staple and cash crops are cultivated and a few, mostly stall-fed ruminants, such as cattle, buffalos, and goats, are kept. Major staple crops include rice, wheat, maize, millet, barley, buckwheat, and potato, most of which are consumed by the farming families themselves, although any surplus may be sold. Cash crops are cultivated to derive income and include high value crops such as vegetables, fruits, spices, tea, and various horticultural products. High value crops are seldom consumed locally, provided there are sufficient staple crops available. The number of cash crops grown is relatively low in most districts and the average quantity produced is limited (468 kg per year) (HICAP PVA). Subsistence farmers also rely extensively on cattle and HICAP studies found that households keep an average of two cattle in the Upper Indus, Koshi, and Eastern Brahmaputra sub-basins, and one per household in the Salween-Mekong basin. The low production cattle that are common in mountain farming systems can place added pressure on grazing land and fodder from forests so now there is a trend in some areas to import high yielding hybrid cows.

The semi-subsistence farms of the HKH have traditionally been well-adapted to local microclimates and made use of the ecosystem services that mountains provide, such as crops, forest products, medicinal herbs, and honey. In Nepal, for example, farmers cultivate different varieties of small millet that are cold-resistant and drought-hardy, and not dependent on rain. Meanwhile barley, with its short growing period, is cultivated in the high altitudes and cold climate of the Tibetan plateau, as well as in the higher altitude of the Koshi basin, especially in Sindhupalchok District. Buckwheat is also commonly grown in the region because it grows fast, suppresses weeds, and attracts insects and pollinators (Sustainable Agriculture Research and Education, n.d.). Yaks and mountain goats are grazed freely at higher elevations, while cattle are more adapted to the hills, and buffalos and goats to the lowland basins where stall feeding systems are practised.

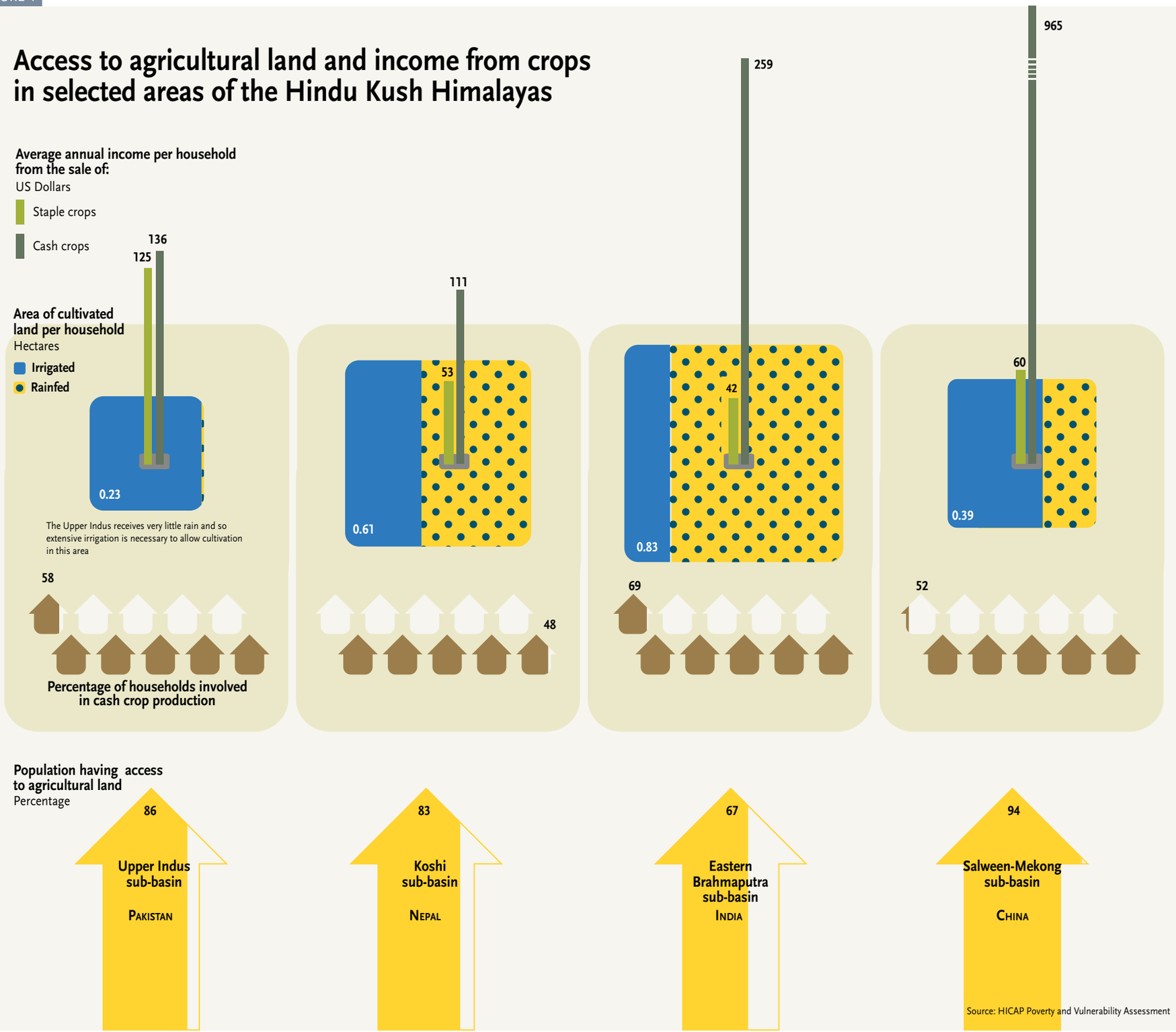
The diversity and resourcefulness which has served farmers in the HKH in the past is now being seriously tested. The HICAP vulnerability assessment showed that 40.1% of households face decreasing yields in their five most important food crops.[6] In addition to devastating natural disasters such as droughts during winter (e.g., Yunnan, China; Chitral, Pakistan) and floods which destroyed crops (Sunsari, Siraha, and Udayapur, Nepal; Assam, India), farmers also reported frost, hail storms, and pests and diseases which have negative long-term effects on animal health or crop quality. Farmers cite examples such as blight and leaf worms in potato and maize; brown leaf spot, leaf roll, and stem borer in paddy; loose smut in wheat, barley, and maize; white grub and stem borer in millet; and liver fluke in livestock occurring at higher altitudes than before.

Historically, societies in the Hindu Kush Himalayas have been very adept at using the inherent flexibility of mountain food systems. This capacity will be much needed as climate change makes its mark. Now it also extends to switching to cash crops and exploring market production. In the traditional subsistence systems of today, many households are involved with cash crop production (Figure 4). In Yunnan province, China, for example, investment goes into tobacco, and to a lesser extent walnuts

6. By basin, the most important food crops are:
Eastern Brahmaputra – main paddy, early paddy, winter vegetables, summer potato, summer vegetables
Koshi – main paddy, summer maize, wheat, lentil, winter potato
Upper Indus – wheat, summer vegetables, summer potato, summer maize, millet
Salween-Mekong – summer maize, main paddy, wheat, spring maize, summer vegetable

FIGURE 4

Access to agricultural land and income from crops in selected areas of the Hindu Kush Himalayas



Source: HICAP Poverty and Vulnerability Assessment

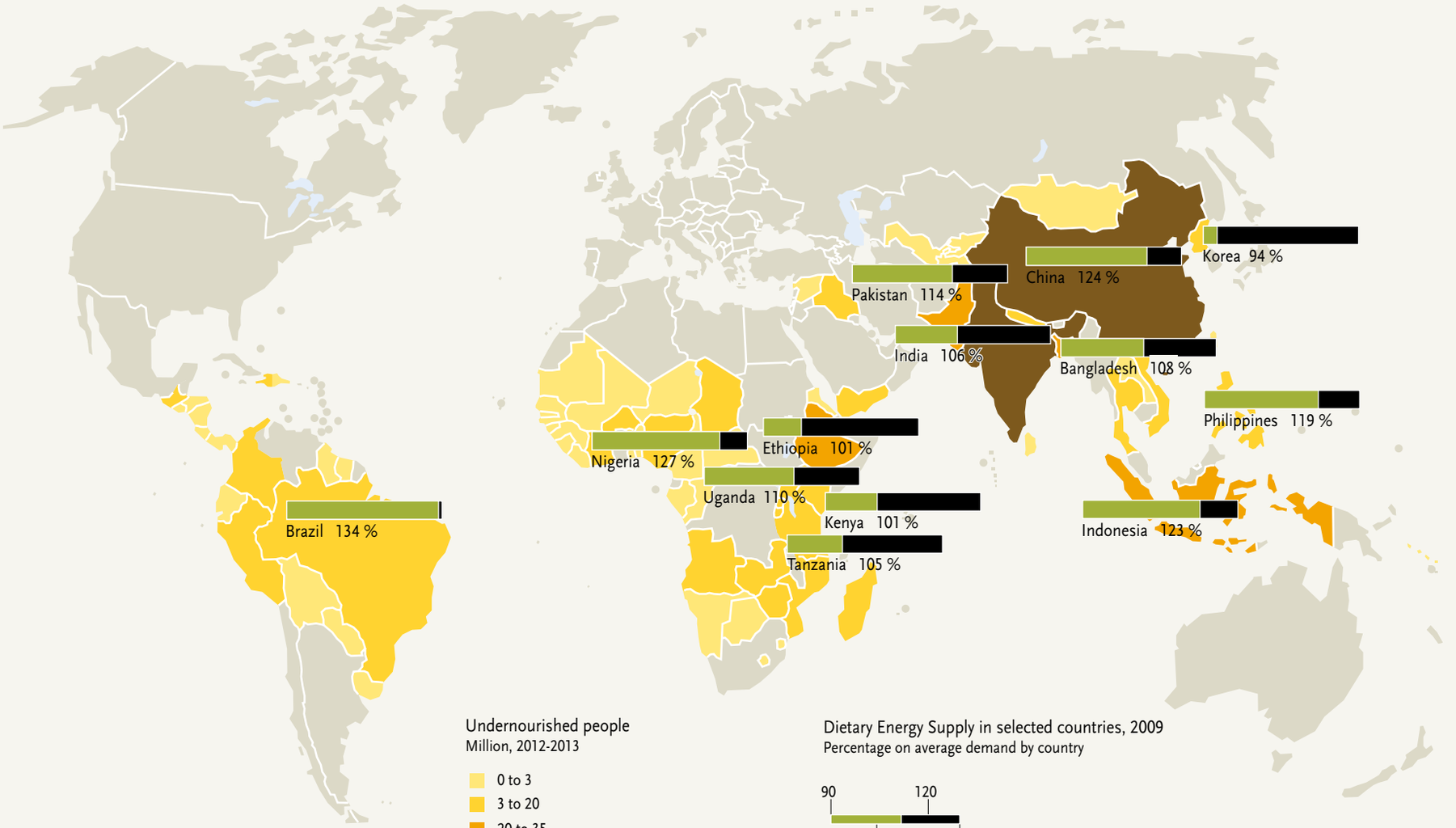
or fruits, and is supported by industry (e.g., providing water management). The same is true for tea production in districts such as Tinsukia and Dibrugarh in Assam, India where the tea industry supports small-scale farmers to test their land for tea cultivation which requires less labour and provides higher incomes. It is estimated that over 47,000 ha of land are in the hands of small tea farmers in the Brahmaputra Valley (Singh and Gosal 2011). The industry provides pesticides and training, as well as contract-farming agreements that settle on a fixed price and fixed amounts to be bought from farmers. In Lakuridanda, Nepal, the growing market value of winter vegetables such as cauliflower, potato, cabbage, carrot, radish, and medicinal herbs convinced an entire farming community to replace their pest-ridden maize and frost-sensitive buckwheat crops with more valuable cash crops.

There are problems associated with these new production patterns, however. Improper soil management and water scarcity threaten production. Yields are still low due to limited land availability. The greater investment in cash crops also means less diversity in production leading to less diverse diets and more vulnerable food security. Crop diversity in all four HICAP study areas is already low and in-depth research in Pakistan and Nepal confirms that low diet diversity is contributing to malnutrition in mountain societies (HICAP PVA).

The impacts of agricultural intensification are visible in all HKH countries and present a challenge to food security even without the additional burden of climate change (Aggarwal *et al.* 2004). Systems that were meant to raise productivity some decades back and which were not based on sustainability criteria now cause land degradation, deforestation, overgrazing, groundwater depletion, water pollution, and pesticide resistance. Chemical fertilizers have replaced soil fertility management, herbicides have replaced inter-cropping systems (Murray 2010), and diversification as a coping strategy to increase resilience of traditional agricultural systems is gradually threatened by cash crop production. In addition, cash crops are also threatened by climate change, just as staple crops are. HICAP field studies found that farming systems are in a process of restructuring due to shifting of flowering and ripening times (Section 4.3). Sowing may be delayed and replanting of seeds is common in situations where crops do not look promising. It is important that when farmers experiment with new crops they consider not only their potential market value but also their contribution to enhancing the resilience of farming systems to climate change.

FIGURE 5

Undernourishment and food supply



Map produced by Chiara Pichierri, University of Bologna

Source: FAOSTAT and ESS calculations

2.2 Food security varies enormously throughout the Hindu Kush Himalayas

"Under the mountains is silver and gold, but under the night sky, hunger and cold."

■ *Asian proverb*

While estimates show that there is currently enough food produced globally per capita, around one in eight people in the world suffers from chronic hunger (Figure 5) (FAO *et al.* 2013). Globally, the total number of undernourished people is decreasing, down from approximately 19% of the world's population in 1990 to 12% in 2011-2013 (FAO *et al.* 2013). But in the countries of the HKH, undernourishment remains stubbornly high. In 1990, there were over 535 million undernourished people living in China, India, Nepal, and Pakistan, about 53% of the world's undernourished people (FAO *et al.* 2013). Today, 48% of the global undernourished population (408 million people) are still found in these same four countries (Figure 6) (FAO *et al.* 2013). The mountain areas of these countries show the highest degree of food insufficiency and persistent undernourishment remains an urgent situation (Chappel and Lavalle 2011; Rerkasem *et al.* 2002).

Understanding the great diversity and variation across the HKH region is key to properly assessing the food security situation. Food deficiency varies tremendously both within HKH countries and throughout the mountain areas. HICAP research, for instance, found that while no households in the Upper Indus, Koshi, Eastern Brahmaputra, and Salween-Mekong sub-basins suffered full food-deficit months, 1–2% of households frequently had to reduce portions, skip meals, or even go a full day without food. Poverty is still considered to be widespread in these areas, and although households have reasonably good stocks of crops, they remain vulnerable to changing environmental and social conditions. Differences in stocks can also reflect differences in population size and density, and available economic income opportunities and higher salary dependency, as in the case of India (Figure 7).

China

According to China's Medium- to Long-Term Food Security Plan (2008–2020), the Chinese government has determined that 350 kg of cereal per capita is needed annually to meet minimum food requirements (Government of the People's Republic of China 2008). At the national level, the Chinese Central Government has been increasing investment into the agricultural sector (27% in 2007, 38% in 2008, and 20% in 2009) (IFPRI, n.d.), and allocated 98 million USD in 2013 to increase agricultural production (Peng 2013). These funds will be used to increase lending in rural areas to help improve productivity and farming conditions.

In general, China considers itself mostly self-sufficient and food secure in the production of rice, wheat, and corn (Blas and Dyer 2009). Their challenges with respect to food security relate mainly to population growth, economic growth, rapid loss of agricultural lands to urbanization, water and air pollution, and land degradation. Growth in the agricultural sector has been achieved from the intensive use of chemical fertilizers and pesticides which are now the biggest sources of water pollution in the country.

In the mountainous region of China, degradation and desertification of rangelands is a major concern. The Tibetan rangeland covers 160 million hectares and consists of 84 million hectares of grasslands. This area is now experiencing rapid degradation caused mainly by overgrazing and over-cultivation, exacerbated by climate change. Overgrazing of the arid temperate rangelands of the Tibetan Plateau increased dramatically from none in 1990 to 30% in 1999 (Han *et al.* 2008). The amount of degraded land was estimated to increase slightly from 14 to 15% in this same period (Han *et al.* 2008). These environmental impacts translate to a loss of livelihoods for the nomadic pastoralists who depend solely on livestock rearing on the Tibetan Plateau.

India

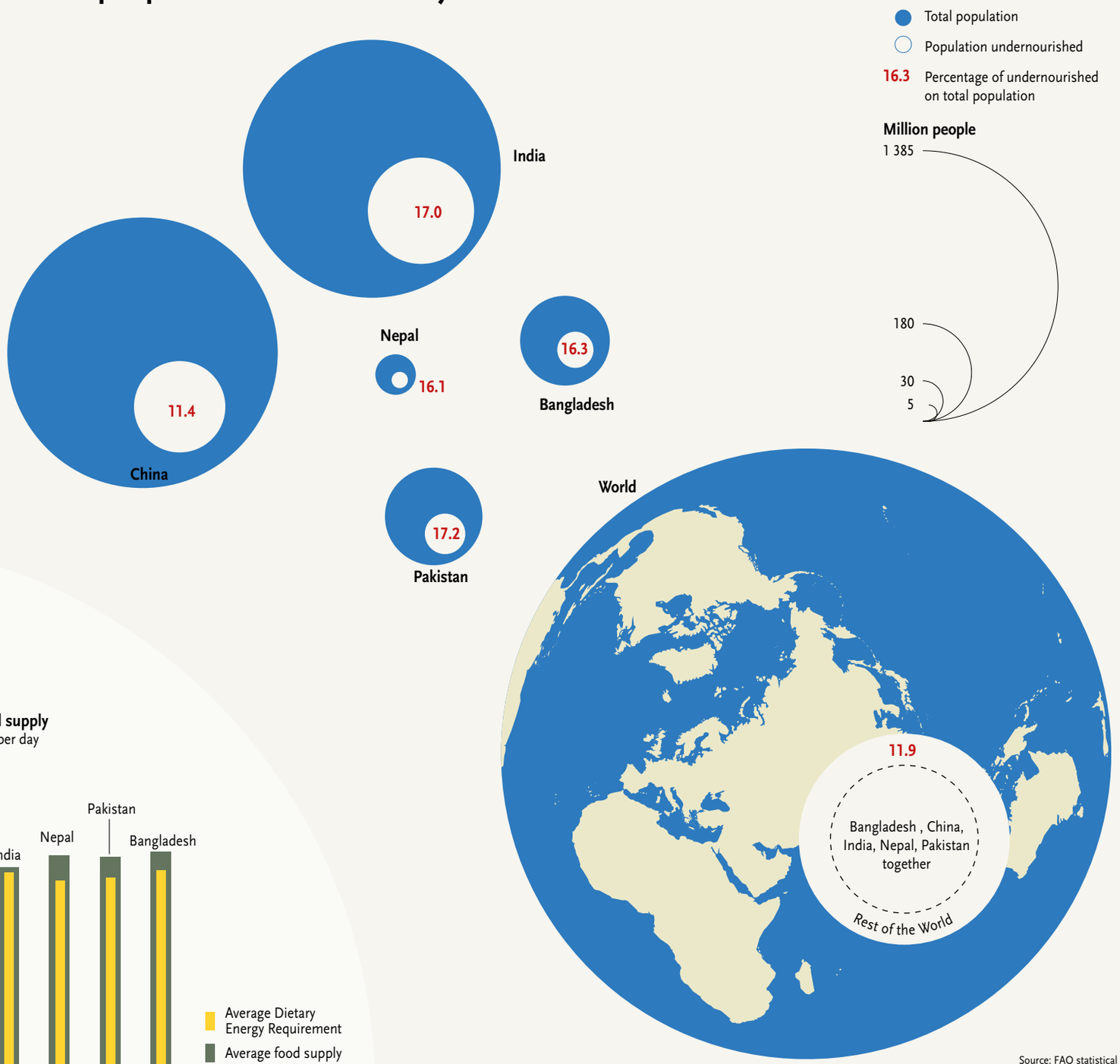
The 2013 Global Hunger Index (GHI) produced by the International Food Policy Research Institute (IFPRI) ranks India as 63rd out of 78 countries, and rates the severity of India's food insecurity as "alarming"[7] (von Grebmer *et al.* 2013). By comparison, neighbouring China, Nepal, Pakistan, and Bangladesh rank 6th, 49th, 57th, and 58th, respectively. Although food security remains a major concern in India, it is most acute in the mountainous regions, where the average dietary energy intake in rural populations is 2098 Kcal per capita per day, 50 units below the national average (Giribabu 2013).

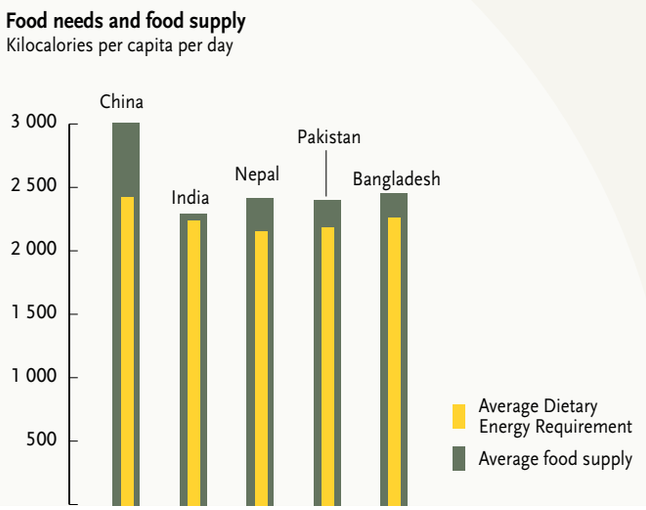
Unlike China, where high economic growth has resulted in significant progress toward meeting food security needs, India's growth since 2000 has not

7. The Global Hunger Index score for each country is calculated by averaging the percentage of the population that is undernourished, the percentage of children younger than five years old who are underweight, and the percentage of children dying before the age of five (von Grebmer *et al.* 2013). The scale indicates the level of hunger from "extremely alarming" to "alarming" to "serious" to moderate" to "low".

FIGURE 6

Undernourished people and food availability



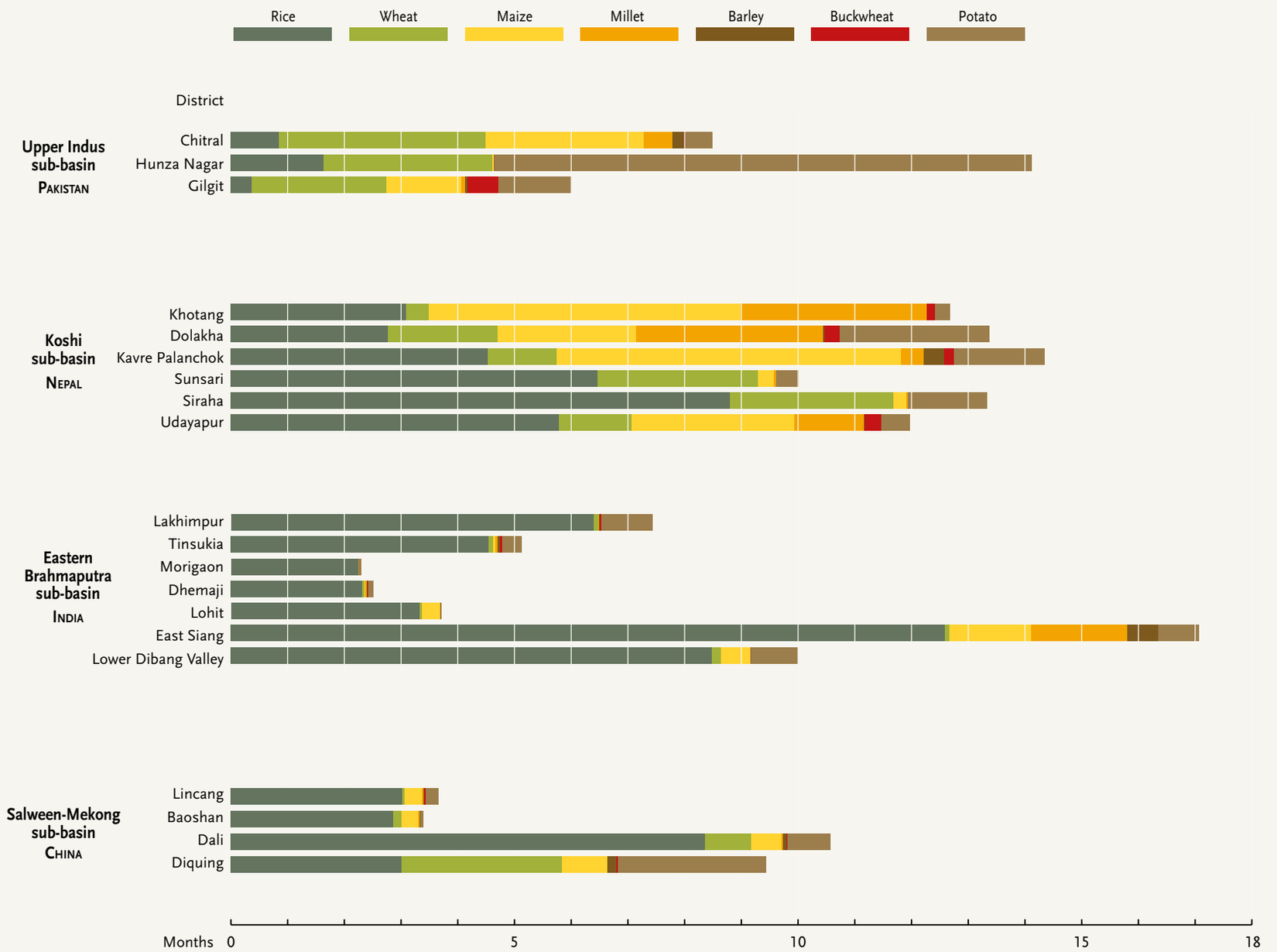


Source: FAO statistical database

FIGURE 7

How long will food stocks last?

Average number of months that stocks of major staples will last to feed all household members



Source: Adapted from HICAP PVA weighted data

had a significant impact on its overall hunger and food deficit situation. In response to widespread food insecurity, the Ministry of Agriculture has implemented the National Food Security Mission (NFSM) in 21 states (Andhra Pradesh, Assam, Bihar, Chhattisgarh, Gujarat, Haryana, Jharkhand, Jammu and Kashmir, Karnataka, Kerala, Madhya Pradesh, Maharashtra, Orissa, Punjab, Rajasthan, Tamil Nadu, Tripura, Uttar Pradesh, West Bengal, Himachal Pradesh and Uttaranchal) (NFSM, n.d.) The NFSM focuses on increasing the production of rice, wheat, and pulses by 10 million tons, 8 million tons, and 2 million tons, respectively, by 2012 (NFSM, n.d.).

Food (in)security in mountain regions – a global concern?

Matthias Jurek, GRID-Arendal

Food (in)security is a major challenge in many of the world's mountain ranges. Given the particular physical characteristics of mountains and associated socio-economic factors, mountain regions all over the world face challenges in terms of food security, although at different levels. Mountains in developing countries are sites of poverty. According to the Mountain Partnership (n.d.), "About 40% of the mountain population in developing and transition countries, or nearly 300 million people, are estimated to be vulnerable to food insecurity. Of these, nearly 90% live in rural areas and almost half of those are likely to be chronically hungry."

From Tajikistan in Central Asia which faces poor transportation infrastructure for access to nutritious food, to Vietnam in South-East Asia where in remote mountainous areas the poverty headcount ratio exceeds 70% (Akramov *et al.* 2010), to Ecuador in the Tropical Andes where there is a high concentration of malnutrition and extreme poverty with 60–70% of population malnourished, hard hit areas can be found in major mountain regions around the globe.

The recently published contributions to the Fifth Assessment Report of the IPCC once again stress that global warming and the melting of glaciers is a global problem (IPCC 2013; IPCC 2014a). Climate change will further worsen the food security situation in many mountain regions. Despite the many challenges, some mountain communities have managed to adapt to the changes. In the Ethiopian highlands/Eastern Africa, current development cooperation has improved cropping methods and capacity building in livestock breeding with the view to raising agricultural output and generating income (Austrian Development Cooperation, n.d.). In Nepal, the High Mountain Agri-business and Livelihood Improvement (HIMALI) Project aims to increase the income and employment of high mountain people by developing their agricultural, livestock and non-timber forest products and improving the rural household livelihoods in high mountain districts (i.e., over 2,000 m above sea level) (Government of Nepal, n.d.).

At the policy level, mountain communities continue to be marginalized, suffering from ineffective policies on various levels. The recently endorsed outcome document of the Rio+20 United Nations Conference on Sustainable Development, The Future We Want, provides some hope by calling for action on mountain global concerns, including on poverty and food security in these fragile ecosystems (UN 2013). The debate on the UN's Post-2015 Development Agenda and the process leading to the Sustainable Development Goals (SDGs) provides a new opportunity to mainstream mountain-related issues into the relevant discussions, including those related to food security and climate change.

India has a long-established public distribution system for food but it has been the subject of much criticism for high maintenance costs, spoiled surplus stocks, bureaucracy, and corruption. In September 2013, the Government of India adopted the National Food Security Act, also known as the Right to Food Act. This Act makes food a legal right and seeks to provide 5 kg of subsidized grains every month to 800 million poor people at the cost of INR 1.3 trillion (USD 23.9 bn) annually (BBC 2013). The Act is based on the findings of the National Family Health Survey 2005-2006 which showed that 22% of Indians are undernourished (International Institute for Population Sciences 2007). By subsidizing food grains, the government aims to reach out to 75% of rural population and 50% of urban population (Gayrathri 2013). Time will show how far this new act can go toward improving the public distribution system.

Nepal

Food security is highly variable throughout Nepal. Overall, the country has a surplus of food which may be stored, yet in 2013, the Government of Nepal identified 27 out of its 75 districts as having food deficits. Most of the food deficit areas are in western highlands, with Humla, Dolpa, Darchula, Bajura, and Mugu having the most severe and chronic deficits. The food deficit districts share a number of characteristics and are characterized by 1) a preference for growing rice grains over traditional local crops such as maize, millet, buckwheat, and potato; 2) outmigration of the agricultural labour force, especially the rural youth population; 3) weak public distribution systems and agricultural extension services; 4) highly variable land productivity, depending on how agricultural practices are implemented through the seasons; and 5) rising food prices. The Nepal Food Corporation provides subsidized food grains in all of these districts.

The import of cereals grew from 180,000 tons in 2009 to 733,054 tons in 2012 indicating the scale of the food deficit in Nepal (Shahi 2013). Demand can be expected to increase as the population is

projected to increase from the current 28.8 million to 36 million in 2025 (Shahi 2013). Rice, for example, is a major staple food in Nepal and is a vital part of the country's economy. Yet in 2013, rice production fell by 11.03% due to a late monsoon, while imports increased by 173% (Prasain 2013). Imported rice is increasingly becoming the single most important grain, both in food aid to food deficit districts and in meeting the demands of emerging urban centres.

Along with other factors, the agricultural sector is being negatively affected by remittance money transferred by foreign workers to their home country (Section 3.3). Remittance money has had the effect of increasing outmigration of agricultural labour to more lucrative jobs elsewhere, as well as developing a new culture of increasing expenditures on consumer goods, including imported food grains. Labour outmigration has also led to the abandonment of land in many areas of the Koshi basin, and is very evident in the Melamchi and Helambu regions.

Pakistan

Food security is a major challenge in the development of Pakistan where the situation has been deteriorating since 2003 after successive flooding events. The largest flooding occurred in July 2010 (Khyber-Pakhtunkhwa and Punjab) in the Indus River basin inundating almost one-fifth of the country. An estimated 17 million acres (69,000 km^2) of agricultural land in the fertile plains was flooded and some 200,000 head of livestock were lost. The longer term effects included damage to agricultural fields requiring additional investment for their rehabilitation, grain shortages in 2011, and loss of stored grains. The September 2011 Sindh flooding inundated 1.7 million acres of arable land. The World Food Programme estimated that in the aftermath of this flood, 70% of the population lacked access to proper nutrition. Ironically, in March 2014, this same province experienced a serious drought resulting in the death of numerous children due to pneumonia and malnutrition.

In Pakistan, 80 out of 131 districts, or 48.6% of the country, do not have access to sufficient food (Guriro 2013). In the mountain provinces, 68% of the population of the Federally Administered Tribal Areas (FATA), 61% of Bolachistan, and 56% of Khyber Pakhtunkhwa (KPK) are food insecure. At the district level, 82% of the population of Dera Bugti in Balochistan is food insecure. Of the 20 most food insecure districts, 19 are in the mountains (ten districts in Balochistan, five in FATA, three in KPK, and one in Gilgit Baltistan) and one in the plains (Sindh), indicating that food insecurity is spread across the country and is a major concern for most districts and provinces, although greater in the highlands than the lowlands. Larger family sizes in Pakistan mean that as much as 46% of the household income is spent on food compared with 35% in India (Guriro 2013).

1 2 3 4 5

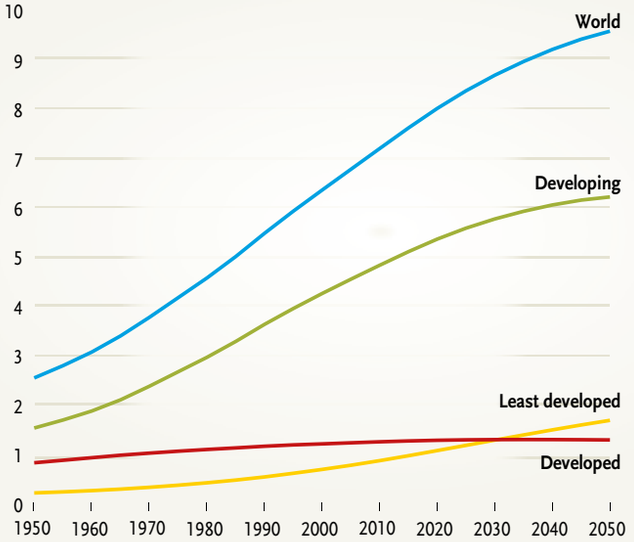
Forces behind food security in the Hindu Kush Himalayas

- The supply chains of mountain outposts are becoming increasingly vulnerable due to climate change and volatile global food prices
- Poverty limits the nutritional value of diets in mountain households
- Declining investments in agriculture, outmigration of labour, and fewer young people in farming are restructuring mountain farming systems

FIGURE 8

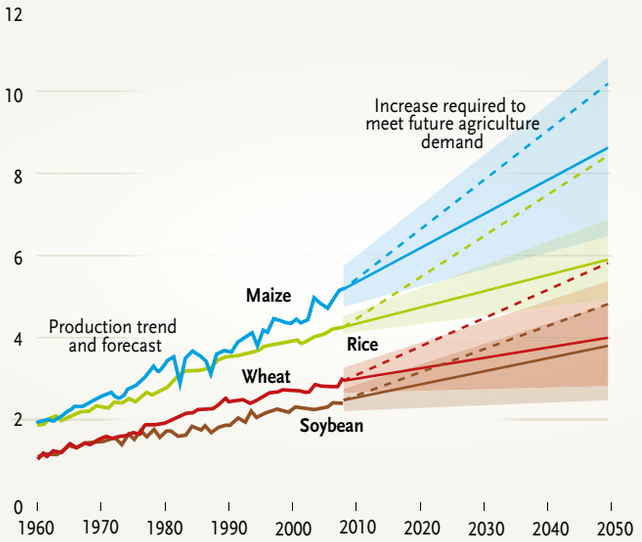
Population increase and food production

Population growth
Billions



Source: UN Population Division, from van der Mensbrugghe *et al.* 2009

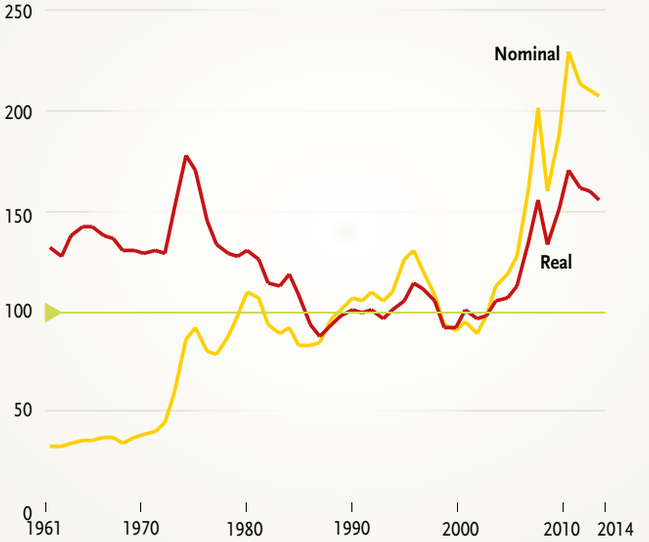
Global yield production trend and projections
Tons per hectare



Source: Deepak, K. R., Yield Trends Are Insufficient to Double Global Crop Production by 2050, PLoS ONE, 2013

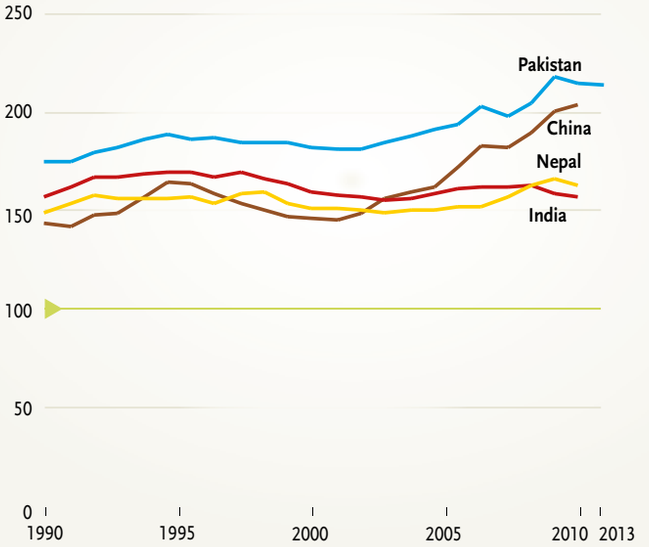
Food price indices

Global Food Price Index
Baseline 2002-2004



Source: FAOSTAT, accessed March 2014

Domestic Food Price Level Index



Source: FAOSTAT, accessed March 2014

3.1 **Rising food prices create regional impacts**

Increasing food prices hit crisis levels in 2007–2008. Despite some recent declines, the overall trend is still upward with prices for both crop and livestock products expected to remain above historical levels (OECD/FAO 2013) (Figure 8). Volatile global food prices result in higher real-world prices over the medium term. In 2007–08, prices in South Asia and China, as elsewhere, skyrocketed due to a combination of forces including weather conditions, low global food stocks, increasing oil prices, rising demand for biofuels, changing food demand, and speculation in financial markets. Higher prices lower the purchasing power of individuals, influencing their expenditure decisions.

Nutritional security is often adversely affected by price hikes, especially among vulnerable populations, as people switch from more expensive, nutritionally varied diets to ones higher in cheaper carbohydrate staples (e.g., rice, maize) (Meerman and Aphane 2012). The Food and Agriculture Organization of the United Nations (FAO) estimated that the 2007–2008 food crisis added another 75 million people to the already 925 million undernourished people in the world (FAO 2008). Food inflation during that time reached double-digit numbers in three of four HKH countries: China (8.7% in 2008–2009), India (10.2% in 2008–2010), Nepal (17.7% in 2008–2009), Pakistan (28.5% in 2008–2009), with rice, pulses, fruits, vegetables, milk, eggs, and meat being particularly affected (McBeath and McBeath 2010; Eapen and Nair 2012; Nepal Ministry of Agriculture and Cooperatives *et al.* 2009; State Bank of Pakistan 2009). Unstable governments and weak monitoring by institutions exacerbated the situation in all areas, but particularly in rural and remote areas.

In all four HICAP countries, biodiversity is high, but there is no simple link between a rich natural environment and food security. Diet diversity in the mountain outposts is generally very low. High crop diversity may not be exploited in optimal ways for a number of reasons. Supply may be adequate at only certain times of the year, labour input may be constrained, technology, tools and knowledge may be lacking at times, and financial constraints may limit the optimal use of crops. Also, crop diversity is reduced when poorer farmers only have small amounts of land to till. Mountain dwellers are often left having to purchase particular food groups that are affected by price hikes (e.g., grains, pulses, vegetables and fruits, animal products, spices) (HICAP PVA).

In the HKH, access is often a more important aspect of food security than availability and production of food (WFP 2001). Food access is particularly dependent on purchasing power and social networks, but also on government policies and institutions. Purchased food contributes 50.2% to food consumption in India, 44.2% in Nepal, 64.8% in Pakistan, and 57.8% in China (HICAP PVA). The increase in purchased food is driven not merely by local and easily observable factors such as limited land for farming. Global markets are increasingly penetrating new areas, creating new desires and aspirations, forcing new products into old economies, and contributing to cultural and social change by diffusing external values in local settings. Recent data from HICAP clearly shows that markets are reaching rural areas, and that contributions from non-agricultural sectors are increasing as a portion of total income (Figure 9).

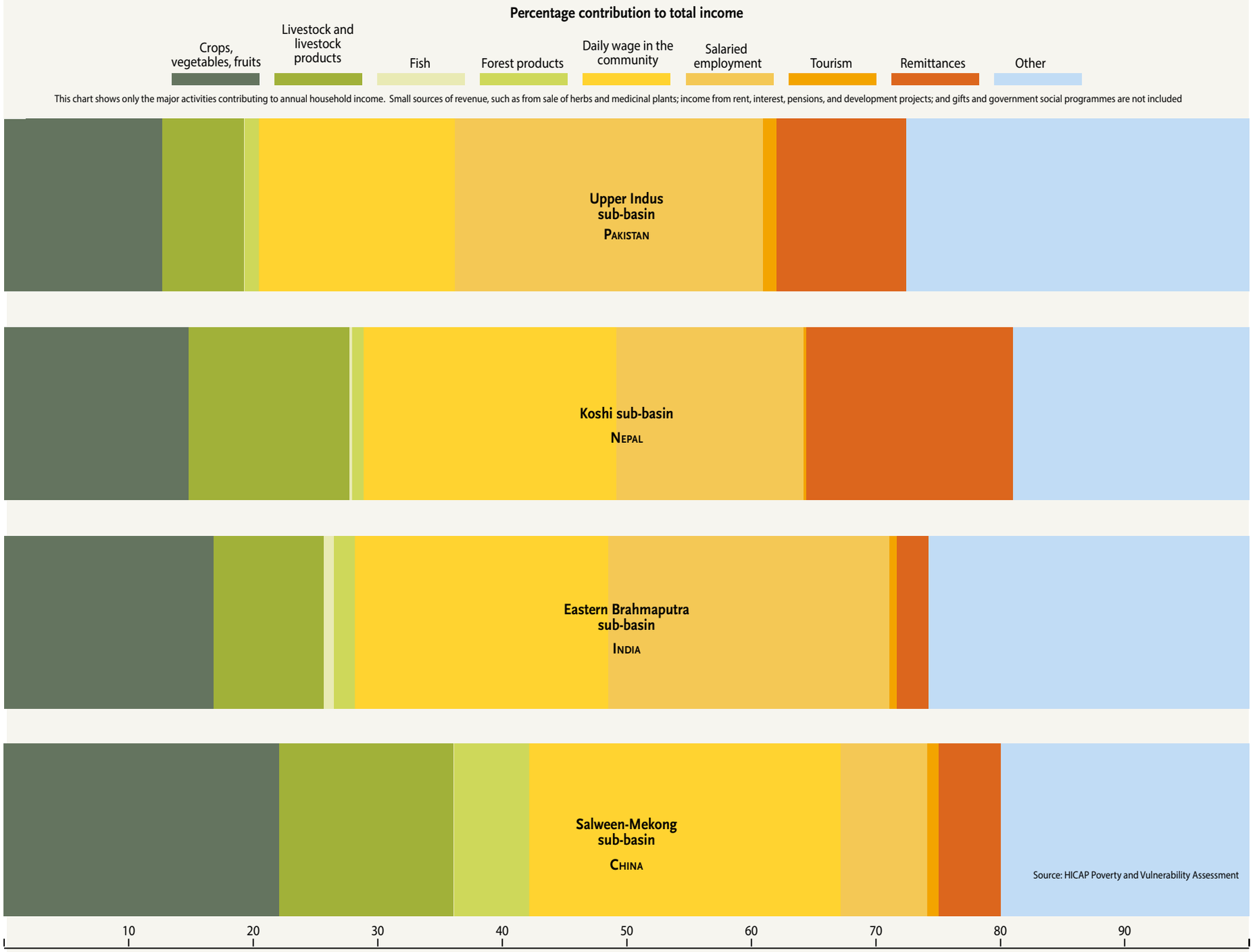
In mountain areas, physical access can also constrain access to food. Many mountain areas are seasonally cut-off from markets due to natural forces such as floods and landslides during the monsoon (e.g., Assam, Arunachal Pradesh in India; Khotang in Nepal), or snow in the mountains (e.g., Yunnan, China; Chitral, Hunza, and Gilgit, Pakistan). During this time, people are entirely dependent on their personal food stocks. New infrastructure can improve access to markets and help improve nutrition (e.g., buying perishables during cold season). Increased reliance on cash economies and products produced at a distance, however, can also make mountain communities more vulnerable because of long supply chains.

Food entitlements refer to the ability to produce food, as well as purchase or receive food from organizations or through social networks. In the mountains, food entitlements have shifted from home production to market production and purchases. Often when the agricultural land permits, mountain farm households invest more in cash crop production (Ives 2006). Family members may also engage in off-farm employment, set up small-scale businesses, or migrate either within the country or abroad to earn a living elsewhere. This changes their livelihood situation and overall vulnerability context. In these situations, farmers depend less on environmental conditions and weather but become more vulnerable to market developments and prices, as well as stability in labour markets and business revenues.

As they integrate further into the broader economic system and markets, farm households in the HKH are affected more by political economies and global trade dynamics. The less dependent farmers are on the market for their own food supplies and the more diversified their production is, the less affected they are by high food prices, they may even benefit from them (Tiwari *et al.* 2008). But entering into larger markets may also allow farmers to make use of new opportunities (e.g., through agreements on the trade between the open borders between Nepal and India). The irony for mountain farmers, however, is that even as global food prices increased in recent years, their farm prices did not. Additional profits are often siphoned off by middlemen and commissioned agents along the value chain.

FIGURE 9

Annual income from farm and non-farm activities



3.2 Poor feeding practices slow essential steps towards food security

Poverty is widespread through the mountain communities of the HKH and it is still a major reason for food insecurity in these communities, especially as it impacts fundamental livelihood factors. Poverty and lack of infrastructure combine to keep the education level of women low. The outmigration of men leaves women to tend the farms on their own (see Section 3.3), affecting both the time and the knowledge they have to properly care for their children. This extends to feeding practices for infants and children, and sound hygiene and sanitation practices. Not only are the children adversely affected by this but the women themselves often suffer from malnutrition as a result of the high energy demands placed on them in conjunction with limited food availability.

Children under the age of five are the most affected by malnutrition. Improving the availability and accessibility of nutrient dense food, however, is not sufficient to address the problem.

"The disadvantage of poor nutrition during pregnancy or early childhood is also carried over from one generation to the next: a woman that has been poorly fed as an infant will have children with a lower birth weight."

■ *Olivier de Schutter (2012)*

Hygiene, health, and food security

Sanne Baker, World Food Programme, Nepal

Food insecurity is compounded by poor hygiene practices. A large number of households use open pits as toilet facilities and get drinking water from open springs. The often miserable hygiene and sanitary conditions, and unsafe water sources in the mountains, invite infectious diseases which hamper nutrient absorption, reduce appetite, and imply nutrient losses. A high incidence of waterborne diseases such as diarrhea have been reported for the mountain districts in the HKH during the rainy season and flooding episodes. In the dry season, when water is scarce, hand-washing and kitchen hygiene are difficult, and so-called water-washed diseases become a major problem. The naturally harsh conditions of the mountains reduce access to the often poor-quality health service, complicating timely and effective treatment of disease.

Agriculture and nutrition in the mountains

Peter Andersen, University of Bergen, Norway

The main cause of malnutrition of mountain people in the Hindu Kush Himalayas is a diet which is highly dominated by cereal grains, with rice often being the most important staple grain. Additionally, mountain people, especially those involved in agriculture, have high energy requirements. The most commonly addressed nutrition problems are protein-energy-malnutrition (PEM), and iodine, vitamin A, iron, and zinc deficiency. However, deficiencies of B and C vitamins, and minerals such as calcium and potassium are also widespread. Stunting – being short for age – is commonly used as an indicator of chronic malnutrition, and in particular of micronutrient deficiencies. According to the World Health Organization (WHO), the national rate of stunting of children below the age of 5 is 47.9% for India, 43% for Pakistan, 40.5% for Nepal, and 9.4% for China (UNdata, n.d.). The highest figures are found in remote mountain areas. In the Nepalese Far West mountain districts of Humla and Jumla, more than 70% of children below the age of 5 are stunted (Central Bureau of Statistics *et al.* 2006). Since chronic malnutrition has long term implications for immune system function, physical and cognitive development, as well as lifetime poverty risk, it is both an ethical and an overall human development problem.

Dietary changes are occurring due to changed cropping patterns, food preferences, and availability of commercial foods. This may have negative consequences when coarse, nutritious grains are replaced by rice or biscuits, or positive as when wheat replaces rice and more vegetables are available. One common problem for the whole of South Asia is the reduced availability per capita of the nutrient-dense grain legumes (beans, lentils, peas) over the last 50 years (Welch and Graham 1999).

"The reduction of poverty alone is insufficient to reduce malnutrition. Likewise, individual agricultural and rural development programs aimed at improving farmer incomes through cash cropping have not consistently demonstrated substantive nutrition benefits, especially for young children."

■ *Herforth et al. (2012)*

"For global development to be sustainable, the issues of climate change, gender equality, and food security must all go hand-in-hand."

■ *Mary Robinson, International Women's Day, 2014*[8]

Exclusive breast feeding for the first six months, for instance, is a lifesaving act for infants in the mountains as breast milk contains all the necessary nutrients, strengthens the immune system, and protects again gastro-intestinal infections. The median duration of exclusive breastfeeding of children in the mountains, however, is only 3.2 months and complementary feeding starts far too early (Ministry of Health and Population Nepal *et al.* 2011). This hampers the nutritional performance of breast milk and increases the risk of malnutrition and disease through contaminated water and food sources. Often, nutrient requirements are not met adequately during the so-called window of opportunity between gestation and 24 months of age. Without adequate nutrition in this critical period, it is almost impossible for individuals to catch up for lost physical or mental development.

The best way to cover all macro- and micronutrient needs is to eat a diverse diet. But the colourful food markets often depicted in pictures disguise the reality that natural conditions and limited crop diversification make it difficult to meet nutrient requirements in HKH countries. Compared to the lowlands and urban areas, mountain households in the HKH, on average, consume the smallest number of food groups. Essential proteins are lacking in the diet as more than 50% of people do not consume meat, fish, or eggs on a regular basis. People also do not consume enough other protein sources, such as milk or legumes that could compensate for these food items. Limited access to and poor use of vitamin A rich crops, such as spinach or pumpkin, and iron rich foods such as meat (in some cases due to religious reasons), lead to vitamin A and iron deficiencies, respectively. Increased workloads may also prevent women farmers from spending sufficient time collecting wild vegetables and fruits (bamboo shoots, bael, fiddlehead fern, wild potato, etc.) or medicinal plants that are crucial to nutritional security and health. In addition, convenient technologies such as pressure cookers can negatively affect the nutritional performance of traditional food items, such as lentils.

Women get less nutrition than men

Sarah Nischalke, ICIMOD

Existing gender roles and family hierarchies lead to food deprivation, especially in households of scarcity. Men eat first while women distribute food and eat last when the rest of the family has finished. Children's food requirements also are often underestimated. Particularly nutritious but expensive items such as meat and fruits are distributed according to cultural considerations rather than physical requirements and age. The result is intra-household food insecurity that adversely affects women and women's health in the HKH.

8. www.trust.org/item/20140307105414-hpkl2

3.3 **Social change challenges the future mountain farming**

Changes in the social structures of Hindu Kush Himalayan mountain communities are changing the lives of mountain farmers. The restructuring process of agriculture is rooted in new expectations of life, the novel dimension of mobility, and new food trends. To many young people, farming is not viewed as an attractive future. No longer perceived as caretakers of the country, farmers are seen as the weakest link in the system. Being a mountain farmer these days means poor education, hard physical labour, and a low standard of living causing agriculture to be viewed as a "socially demeaning occupation" meant for the illiterate (Hoermann *et al.* 2010).

Despite the poor perception of agriculture and declines in the agricultural sector over recent decades, it remains a significant employer in South Asia. More than 50% of the population of Bangladesh, Bhutan, India, Myanmar, and Nepal work in agriculture, as does 45% of the population of Pakistan (World Bank, n.d.). Only China has seen major reductions in this sector, down from 69% of the population in 1980 to 37% in 2010, largely as a result of increasing industrialization. Clearly, agricultural sector programmes are essential not only for ensuring food security but also for supporting an important employer for the majority of HKH countries.

One of the greatest social challenges to farming in the HKH is from the outmigration of labour. Migration is a source of social and financial remittances for many households. These remittances not only help fulfill basic needs (e.g., purchasing food) but can also help people recover from disasters (e.g., reconstructing houses after floods), prepare for disasters (e.g., investing in irrigation in drought-prone areas or purchasing boats in flood-prone areas), and adapt to climate change (e.g., purchasing drought-resistant seeds or acquiring new technology). Yet, the overall motivation for migration is to generate cash for consumer goods, health, and education, not to generate investment for mountain agriculture.

Outmigration is not new to this region but it now occurs to a greater extent and to a greater number of destinations, boosted by the economic upturn in urban centres in the Gulf countries and Southeast Asia. Fifteen percent of the 200 million labourers worldwide come from HKH countries, many of them from the mountain regions (Banerjee *et al.* 2011). In 2010, total remittances received from abroad amounted to 55 billion USD in India, 51 billion USD in China, 9.4 billion USD in Pakistan, and 3.5 billion USD in Nepal (Banerjee *et al.* 2011). Mountain dwellers are increasingly aware of opportunities outside of their regions and abroad. Mobile phones, radio, internet, and television promise income opportunities while reduced transportation costs make travel more accessible.

HICAP research shows that off-farm employment is a popular livelihood strategy but one that results in frequent labour shortages on farms (57% of households in Nepal; 31% in China; 13% in Pakistan; and 28% in India). Households report family members engaging in salaried labour for at least ten months of the year (43%), setting up small-scale businesses (28%), and migrating within their own country (27%) or abroad (9%) to earn a living and send remittances home (HICAP PVA).

Migration is also a highly engendered process in the HKH with up to 40% of men absent (Hoermann *et al.* 2010). More and more, it is women and the elderly who are left to tend the farms, with the overall effect of feminizing agriculture and whole mountain economies. Remittances often do not compensate for the missing male workforce as many migrants are poorly paid. When the money is not sufficient to employ additional

farm labourers, families are at greater risk of being food insecure. In some locations, female famers will lease out land for labour and share in the output of the farm. In cases where remittance earnings are good and women become the de facto heads of households, they tend to make better decisions for child nutrition and spend more on children.

As farming becomes more feminized, it brings major challenges not only for women themselves but also for households and the family structure. Women tend to be disproportionately affected by climate change and emerging disasters because they lack access to information and resources, and are limited in their mobility and capacity to participate in decision-making (Verma *et al.* 2011). They are not well-represented in the policy landscape yet they are crucial food and risk managers, and most affected by changes in resource governance.

"The prices in the market influence our production. We try to sell only if the prices are high. But the prices for the cultivation are going down, so that the young generation does not intend to work in cultivation work anymore. The youth go to Chennai. There they can earn 10,000 Indian rupees per month, investing much less in work and buying things from the market. We are engaging four, five, six family members in the paddy. If one person goes outside for work, he will earn the same money much more easily and can look after the family in a reliable manner. With agriculture, there is not even a guarantee that you can fulfill the family needs and cover family expenditures."

■ *31 year-old farmer, Lower Laopani, Assam, India*

Climate change: The last straw … or catalyst for inevitable change?

- Future water supply will be less predictable and less reliable
- The balance between glacial melting and rainfall will be critical for future food security
- Increasing rainfall variability and more extreme weather events will lower agricultural productivity

"It is projected that climate change will affect food security by the middle of the 21st century, with the largest numbers of food-insecure people located in South Asia."

■ *IPCC Fifth Assessment Report (Hijioka et al. 2014)*

"In the glacier-dependent Himalayan region, excessive runoff and flooding will threaten livelihoods."

■ *IPCC Fifth Assessment Report (Olsson et al. 2014)*

4.1 **Water availability is a dynamic factor in food security**

Achieving food security without a stable and predictable water supply is not possible. The Hindu Kush Himalayas – the water towers of Asia – provide water for agriculture, electricity generation, industry, and basic household needs for over one billion people downstream. Yet water scenarios for the HKH warn that under a warming climate, the water supply from the Hindu Kush Himalayan glaciers is becoming less reliable. In the near term, these glaciers are expected to release more water than usual, then diminish gradually over the longer term to significantly reduced volumes (Immerzeel *et al.* 2010; Douglas 2009; Krishna 2005). Although there will be variation to this pattern across the HKH region, overall, increasing demand and poor water management are expected to pose serious challenges throughout the region (Hijioka et al. 2014).

HICAP studies indicate that there will be no significant changes in water availability in the Salween, Mekong, Ganges, Brahmaputra, and Indus Rivers until 2050 (Lutz and Immerzeel 2013). It is thought, however, that climate change impacts will be felt more quickly in the Indus River as glacial melt plays a much larger role in the flow of this river (44.8%) than the others (Immerzeel *et al.* 2010; Kaser *et al.* 2010).

The IPCC Fifth Assessment Report projects rising temperatures, high rainfall variability, and increases in extreme weather events for Asia which are likely to

Food, water, and energy security in the Hindu Kush Himalayas needs a nexus approach

Golam Rasul, ICIMOD *(based on Rasul 2012)*

The FAO estimates that global food production must increase by 70% by 2050 to meet the demands of more than 9 billion people (FAO 2009). The majority of these people will live in Asia, adding increased demand for water and energy into the calculation. The Hindu Kush Himalayan mountain systems provide ecosystem services for agriculture and supply water and energy to downstream areas in the HKH countries. There are strong linkages between food, water, and energy security. Water is needed for agricultural production but also to generate energy through hydropower. Energy is needed for agriculture, food processing, storage, and transport, as well as for water treatment and wastewater disposal. The demand for all three is increasing as a result of growing populations, industrialization, urbanization, and economic growth in the HKH. Agricultural intensification has led to a great dependency on water and energy so that energy prices also affect food prices (transport, irrigation, fertilizer, processing, and marketing. Overall, productivity needs to be increased on the amount of currently cultivated land.

Watershed management and the protection of forests, wetlands, and rangelands are crucial in sustaining ecosystem services and ensuring their resilience. This includes restoring natural water storage capacity, and providing incentives for mountain communities to manage watersheds, wetlands, and biodiversity in a sustainable manner. Adopting sustainable agricultural practices, including good water management and energy-saving technologies, will also contribute to the conservation of ecosystems and watersheds. All of these measures will be necessary for improved food security in the region.

"Floods, droughts, and rainfall patterns are expected to negatively impact crop yields, food security, and livelihoods in vulnerable areas."

■ *IPCC Fifth Assessment Report (Hijioka et al. 2014)*

result in declining agricultural productivity, especially of cereals (Hijioka *et al.* 2014). Agriculture in the HKH will be particularly affected by changes in water supply. Food production will be disrupted by variation in monsoon onset and duration, and frequency of floods and droughts (Douglas 2009). There is, however, still a lack of sufficient and accurate data for assessments in the HKH mountain region because hydro-meteorological data for historical time series is scarce and high-elevation weather stations are few.

The HKH region is heavily influenced by the southwest monsoon during summer and westerly disturbances in winter. This is a region where the majority of the population depends on rain for agriculture, and the pre-monsoon and monsoon account for 88% of the rainfall (Bookhagen and Burbank 2010). Precipitation varies from 3000 mm in the Eastern Himalayas to 100 mm in the southern plain desert on the Western side. The Brahmaputra and Ganges Rivers rely on monsoons and glaciers, whereas the Indus River depends much more on melting of snow and glaciers (Rajbhandari *et al.* 2013). Historical analysis (1951–2007) shows that the wettest years were recorded in the 1950s, while the last decade was the driest, indicating a trend of drought (Shrestha 2012). Apart from some positive increases in precipitation over the east Himalayan belt, intensity and quantity decreases, especially on the southern slope/central part of the HKH. For temperature, annual statistics show a warming trend: minimum winter temperatures are increasing as are extremes in maximum temperatures, especially in higher altitudes (Shrestha 2012).

4.2 Impacts of climate change on food security vary across the Hindu Kush Himalayas

The climate trends in two environmentally and socially distinct basins illustrate future challenges for food security in this region. The Upper Indus basin is composed of the Hindu Kush, Karakoram and Himalayan mountain range and the lower part of the southern plains. It is the primary source of water for downstream areas and supports the world's largest irrigation system in Pakistan and India. Over 200 million people in Pakistan, India, Afghanistan, and China either directly or indirectly depend on this river basin. The lower part is now one of the most water-stressed areas in the world (Archer *et al.* 2010). Projections indicate that the basin will progressively and significantly warm in the future with the upper part of the basin more affected than the lower part. Temperature rises will be higher in winter compared to other seasons. The maximum temperature rise is estimated at 1–1.5 degrees in the 2020s, reaching 4–6 or 8 degrees towards the end of 21st century (Rajbhandari *et al.* 2012). The Upper Indus in particular will face a sharp increase in the amount and intensity of precipitation towards the 2050s, especially in the monsoon season, so that the risk of floods and flashfloods will increase towards the end of the 21st century. The southern plains, meanwhile, will see a decrease in precipitation, making them even more drought-prone and water-stressed than they already are (Rajbhandari *et al.* 2012). Both trends will likely be devastating for agriculture and food security.

The Koshi River basin is a key transboundary basin in HKH, shared between China, Nepal, and India, with a population of almost 40 million people. Because of its diverse topography, young geological formation, high degree of glaciations, and strong monsoon influence, it is likely that climate change will increase its exposure to natural hazards such as landslides, glacial lake outburst floods (GLOFs), droughts, and floods. Long-term trend analysis (1975–2010) shows significant warming trends in minimum and maximum temperatures, especially in the mid-hills, higher Himalayas, and the Tibetan part of the basin (Sharma *et al.* 2012). The maximum temperature during winter and monsoon season is rising, cool days and nights are decreasing, particularly in higher elevations, and dry periods are more common (maximum temperature by 0.30°C/decade, minimum temperature by 0.10°C/decade) (Sharma *et al.* 2012). The frequency and magnitude of weather extremes increases the negative effects on agriculture.

Both basins are experiencing climate trends that will change the nature of their ecosystem services (Immerzeel *et al.* 2010; Xu *et al.* 2009). Pronounced trends in the HKH include warming and drought-proneness in China and the Koshi basin, increased winter water stress in South Asia, high variability in monsoon and flood-related disasters in the Upper Indus and plain areas of other basins, and warming in higher altitudes in all basins. All these trends present a high risk to agriculture. Even though warming will enhance hydrological cycles, water availability (temporal and spatial) will be very vulnerable to climate change. Higher rates of evaporation and the greater proportion of liquid precipitation are likely to affect soil moisture, groundwater reserves, and the frequency of flood and drought episodes (Aggarwal 2008). The extensive decrease in storage capacity will affect water supplies for agriculture, hydropower potential, and other uses.

"Natural events have always had a say on the performance of agriculture in all countries and societies. Weather is probably the biggest source of threat to crop cultivation among all perils."

■ *Ghosh and Sekhar (2013)*

4.3 Farmers continue to change their practices to achieve food security

Good projections are difficult since there is a lack of disaggregated data for mountains but yields of rain-fed rice, corn, and wheat are in particular expected to decline. Estimated reductions are highest for maize (40%), followed by rice (10%), and wheat (5%) (Singh *et al.* 2011). In Pakistan, negative trends are projected for wheat yields in the foothills (Swat District) while positive trends are seen in the Chitral mountains, related to a decrease in growing season length (Hussain and Mudasser 2007). Grassland for livestock is expected to shift northward, and rising temperatures and decreasing water availability will likely adversely affect animal health and reduce milk yield. Decreasing agricultural output directly impacts the rural poor whose livelihoods depend on them, while urban poor will suffer from future food inflation. The risk of hunger and food insecurity due to climate change will likely increase (Hijioka *et al.* 2014). In all HKH countries, the fast growing economies and limited land resources make intensification and increased productivity a matter of water availability and use efficiency (Alagh 2001). Competition for resources and land adds further pressure because people from flood-affected and arid areas are likely to move to the hills and mountains, as seen, for example, in the Chittagong Hill region of Bangladesh (Singh *et al.* 2011).

Observations of farmers in HICAP study areas in India, Nepal, Pakistan, and China reflect observations at the basin level (see table next page). The surveys reveal that farmers are struggling to maintain food security in the context of climate change and environmental degradation. The perceived changes are also reflected in adaptations being taken by farmers. Most common are changes in farming practices (undertaken by 15% of households). These include delayed sowing (especially of grains such as paddy) and harvesting, as well as re-sowing of crops such as maize, barley, buckwheat, or vegetables. Traditional staple crops such as paddy, maize, or wheat were given up by 12% of households, and livestock varieties such as cattle and goats were abandoned by 5% of households. In Koshi, Eastern Brahmaputra, and Salween-Mekong, a large number of households have not applied any strategies (60%, 58%, and 45%, respectively), because they often lack resources and, therefore, have limited ability to take risks by changing anything.

In Lakuridanda, Nepal, people abandoned wheat due to dried water sources, changed rain patterns, and decreased soil moisture. Maize and buckwheat were replaced by potato, winter vegetable production, and medicinal herbs because of better market values. Environmental factors such as resilience to climate change along with migration have also contributed to these transformations.

A farming system under climate stress – Tinsukia, Assam, India

Sarah Nischalke and Suman Bisht, ICIMOD

In Eastern Tinsukia, small floods are a common occurrence in the area and not always a harbinger of bad news. The farmers have learned to live with and adapt to floods. They established farms, and were self-sufficient in their major food crops (rice, mustard, and vegetables), had a decent amount of livestock, and could sell some surplus food in the market. The occurrence of one destructive off-season flood in September 2012, however, has put the farming system under extra stress. It destroyed paddy and vegetable crops in the fields, food and seed stocks in the houses and killed hundreds of cows, goats, and other livestock that used to serve as a food source and a social safety net.

"The climate has already changed so much and we are dependent on water. After the floods last year, now it has become the time of drought (before monsoon). There is no rain but we are obliged to cultivate. If not, we have nothing to eat. I need to hire labour and buy machines to pump water so that I can produce the product. If in the future the floods come more frequently and spoil the paddy cultivation, then we need to expand vegetable cultivation in winter. We need to survive. Otherwise we need to go and find different lands or work for others. My youngest son started planting many different fruit trees. But now he was discouraged by the floods and has left to earn money outside. He had a lot of interest and was the family's innovative mind."

■ *60 year-old farmer, Lower Laopani, Assam, India*

Farmers' perceptions of global environmental change (GEC)

GEC aspect	Eastern Brahmaputra (India)	Koshi (Nepal)	Upper Indus (Pakistan)	Salween-Mekong (China)
Onset of monsoon	Delayed	Delayed	Slightly advanced	Delayed
Annual precipitation	Annual amounts significantly decreased; decreased rainy days but increased intensity; erratic patterns	Annual amounts decreased slightly; decreased rainy days but increased intensity; erratic patterns	Annual amounts increased; increased rainy and intensity; decreased snowfall days	Annual amounts decreased; increased intensity; erratic patterns
Winter precipitation	Decreased	Decreased	Increased	Decreased
Weather extremes	Hot seasons hotter, cold seasons colder	Hot seasons hotter, cold seasons colder; higher frequency in cold and heat waves	Hot seasons hotter, cold seasons colder	Hot seasons hotter, cold seasons colder
Temperatures	Warmer temperatures; slightly to significantly warmed	Warmer temperatures; slightly to significantly warmed	Warmer temperatures; slightly to significantly warmed	Warmer temperatures; slightly to significantly warmed
Productivity trend in important crops	Decreases in staple and cash crops (exceptions: onion/winter vegetables)	Decreases in major staple and cash crops	Decreases in staple crops, increases in cash crops (apple, cherry, pear)	No change in major staple and cash crops
Crop disease and pests	Livestock disease and insect attacks increased	Livestock disease and crop pests increased	Livestock disease increased	Livestock disease and crop pests increased

Note: Farmers' perceptions were obtained through the HICAP PVA household survey in form of rankings and open questions, and supported by in-depth studies in locations in Assam, India; Chitral, Pakistan; Dolakha, Nepal; and Yunnan, China.

Remote sensing for food security in the Hindu Kush Himalayan Region

Faisal Mueen Qamer and Birendra Bajracharya, ICIMOD

Timely crop forecasts are necessary for sound policymaking, planning, investing, and marketing This has stimulated the need to develop data collection and analysis systems across multiple scales. Remote sensing holds significant promise for developing more reliable and economically viable measures of vegetation production dynamics over large areas. In a study on grassland dynamics of the Upper Indus basin, remote sensing-based time series of vegetation and climate data were used to characterize the vegetation dynamics in four distinct bioclimatic regions. The results showed that productivity in the humid sub-tropical region is related to annual rainfall while in the alpine region it is related to mean annual temperature. This suggests that recent climate trends are beneficial to grassland productivity in the humid sub-tropical region and disruptive in the alpine region.

This kind of spatial information can be used for planning and regulating grazing areas in the region to sustainably meet grazing needs. The information on productivity and its trends can be effectively used to support informed decision-making for intra-annual and long-term grazing management. Integrating remote sensing methods and information into vegetation assessments is crucial for achieving reliable production estimates.

"The current water source is not sufficient even for drinking purposes so there is no chance of irrigation for crops and vegetables."

■ *Tamang woman, Chinke, Dolakha, Nepal*

"We only plant those crops which need less water."

■ *Female water-user group in Ahaldanda, Dolakha, Nepal*

Flexibility is a viable response to uncertainty

Tor H. Aase, CICERO

Climate change means more variable weather which exposes farmers to an increasing level of uncertainty. Uncertainty, as opposed to risk, cannot be estimated. Farmers' capacity to cope with unstable weather is largely determined by their flexibility, which implies that farmers can choose between a range of different production options that are open to them. In contrast to innovation, flexibility refers to crops or technologies farmers are familiar with, but which are not cultivated or practiced at present. In the Trans-Himalayan valley of Manang, four flexibilities of the local farming system have been identified (Aase *et al*. 2009):

Firstly, cultivation can be shifted from the slope to the previously uncultivated flat valley bottom where recent temperature increases have prolonged the frost-free season and water is more accessible.

Secondly, a drier climate can be met by reverting to more resistant cultivars like barley instead of growing wheat, a crop which has increasingly substituted barley during the last decades.

Thirdly, conspicuous consumption of items that give local merit can be substituted by items that do not take a toll on local agricultural production. One option in this area is to reduce the number of unproductive horses which would free more land for human food.

Fourthly, lack of labour power due to migration has left a lot of agricultural land abandoned. Land works like a fat reserve that migrant families can live off if labour markets or businesses should fail. Farmers can keep the land in abeyance instead of selling it to other potential cultivators.

The first three flexibilities are site-specific to Manang and other similar locations. The fourth one, however – abandoned land – is widespread throughout Nepal, especially in the Middle Hills and in Trans-Himalayan valleys where migration to domestic cities and abroad is substantial. Keeping cultivable land empty is optimal for the farmer whose main concern is to ensure food security for the family in a situation of increasing uncertainty. But what is optimal for the farmer proves to be sub-optimal for the country whose expressed goal is to achieve national food security.

1 2 3 4 5

The way forward

"People are interested in experimenting but have little knowledge and money. Around half of the villagers gradually started to follow my practices. Of the 100–165 villagers, 50% are experimenting and trying new practices, crops, etc., and observe my cultivation. They have their limitations and due to the floods were very discouraged in their farming. Maybe in the future we will have to invest more in winter vegetables. According to my experience people only cultivate paddy. It is important to their diet. But if they cannot grow paddy, they will have to grow winter vegetables. During winter there is less rain but there is no risk of flood to do so. In summer, it is too much and in winter, too little water."

■ *Indian farmer, 45, Lower Laopani, Assam*

"Increasing regional collaboration in scientific research and policy making has been suggested for reducing climate change impacts on water, biodiversity, and livelihoods in the Himalayan region."

■ *IPCC Fifth Assessment Report (Hijioka et al. 2014)*

The state of food security in the Hindu Kush Himalayas is the result of a complex mix of both environmental and socio-economic factors. Just as there is no single cause of food insecurity, there is no single response to it. The factors driving food insecurity range from variability in climate and weather to environmental degradation, from outmigration to global market forces. Some drivers, such as poverty, are deep-rooted in the region. Others, such as the impacts of climate change, are emerging issues that are expected to become more severe in the coming decades. Influencing these pressures is often beyond the reach of mountain communities. What can be done, however, is to help farmers enhance their resilience to changing conditions through better knowledge, education, and agricultural policies.

Recommendations

Fill in knowledge gaps about food production systems, their efficiency, resilience, and capacity to support mountain populations of the Hindu Kush Himalayas. Policies and actions intended to improve food security in the HKH require sound information about the food systems in the region. There is currently a lack of adequate information about the basic elements of food security – availability, access, use, and stability – in the HKH region. There is a great need for more comprehensive data on status and trends in order to prioritize areas, communities, and actions efficiently.

Target youth in farming. The farming population is already dominated by elders, and demographic changes occurring in the region mean that fewer young people are likely to engage in small-scale farming in the near future. Scaling up investment in mountain agriculture will help attract youth and skilled workers to agriculture, and help retain mountain communities. There is an urgent need for different incentives, particularly in the form of training programs for sustainable and climate-smart farming, that will stimulate younger people to maintain and develop mountain farming systems as pillars in future sustainable food production. Greater efforts should also be made to identify and harness opportunities in mountain agriculture and livestock production.

Support greater diversity in small-scale farming. Develop policies, incentives, and mechanisms to support smallholder farmers to enhance and use the inherent flexibility in their farming systems. Future sustainable food production will increasingly rely on greater local production diversity and agricultural systems which can provide critical ecosystem services for food systems (e.g., water regulation, genetic diversity, pest control, nutrient rich soils). Efforts should also be made to promote indigenous crop varieties which are often much richer in nutrients and may be more resilient to climate change.

Apply gender-sensitive farming approaches. Climate-smart technologies and new programs need to be re-evaluated through a gender lens. Changing opportunities due to migration and climate change require restructuring in farming systems. The introduction of new crops and technologies must be evaluated not only on an economic basis, but also in consideration of labour intensity and gender roles in agriculture (e.g., equipment that are more suitable for use by women).

Strengthen education and build effective networks for knowledge sharing. Societies, individuals, and communities across the world are challenged by food insecurity. This can spur a range of adaptations and innovations through new policies, pilot projects, and monitoring in order to cope with climate change and vulnerability in widely different environments. Access to relevant and updated information can speed up adaptation and innovative development. Concrete experiences and strategic thinking are required for effective policies. An HKH regional network for sharing lessons on improving food security will facilitate broad dissemination of concrete experiences and strategic information for effective policies. This should include a use of a variety of media tools to broadly disseminate information on improved farming practices and markets.

Integrate food security development goals into policies addressing climate change adaptation. Climate change adds to existing environmental, economic, and political stressors affecting mountain livelihoods. Land use and development policies need to emphasize that local agricultural production and purchasing power are the key determinants of food security. Policies and strategies for adaptation to climate change should to include specific food security targets, including strengthening investments, as well as more climate resilient practices in the agricultural sector.

Globally, mainstream mountain-related issues into the United Nations' current discussion on the Post-2015 Development Agenda and Sustainable Development Goals (SDGs). Both Agenda 21 of the 1992 Earth Summit (Chapter 13) and the recently endorsed Rio+20 outcome document, The Future We Want, call for sustainable mountain development. Of particular importance to mountain communities are goals relating to poverty, water and food security, climate change, energy, biodiversity, and environmental sustainability. The establishment of mountain-related targets and indicators related to these goals should be supported.

"There are many potential adaptation strategies being practiced and being proposed but research studies on their effectiveness are still few."

■ *IPCC Fifth Assessment Report (Hijioka et al. 2014)*

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