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Commentary

Dual Challenge of Climate Change and Agrobiodiversity Loss in Mountain Food Systems in the Hindu-Kush Himalaya

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In the Hindu-Kush Himalaya, around one-third of the population is food insecure. In the last three decades (1991–2020), the dual challenge of climate change and agrobiodiversity loss has had a serious impact on the sustainably of food systems in the region. Without tackling this dual challenge, it is difficult to achieve sustainable food and nutrition security.

Mountains cover around 32 million km^2 (22%) of the global land surface and accommodate around 1,010 million people (67% rural). Of the total global mountain area, 63% is located in developing countries, accommodating 91% of the global mountain population. Globally, around 40% of mountain people are vulnerable to food insecurity (projections for 2020 based on statistics in a report from the Food and Agriculture Organization of the United Nations [FAO][1]). The Hindu-Kush Himalaya (HKH) is one of the most important mountain regions in the world; it extends 3,500 km across eight countries—Afghanistan, Bangladesh, Bhutan, China, India, Nepal, Myanmar, and Pakistan—and covers an area of 3.4 million km^2 accommodating 240 million people.[2] In the HKH, around one-third of the population is food insecure, and almost half suffers from malnutrition (children and women are the most severely affected).[3]

In the HKH, the food security of the local people heavily depends on a local base of natural resources despite considerable variation in agro-ecological potential across regions. Overall, subsistence agriculture and livestock remain key sources of livelihoods. Some non-agricultural income sources, such as remittances, small businesses, medicinal plants, wage labor, and tourism, also contribute to mountain livelihoods.[3]

However, food systems in the HKH are facing the challenges of low productivity, poor infrastructure, inadequate access to markets and institutional services, vulnerability to natural hazards, and high cost of food production and transportation.[4] In the last three decades (1991–2020), climate change and agrobiodiversity loss have posed a serious challenge to the sustainably of food systems and overall food security in the region. Climatic changes—such as changes in temperature and precipitation patterns, frequent floods, prolonged droughts, and fluctuations in the timing of seasons—are not only affecting food production and income but also resulting in social inequalities (women and other marginalized groups are the most vulnerable). Simultaneously, the loss of agrobiodiversity is affecting the dietary diversity and overall nutrition security of the people. A decline in traditional food crops and native livestock is the major factor resulting in the loss of agrobiodiversity. However, some climate-change-induced factors, such as the degradation of land and pastures and the adoption of high-yielding crops to compensate for the climate-induced productivity loss, are also adding to this challenge.[5] There is an urgent need to tackle the twin challenges of climate change and agrobiodiversity loss to achieve sustainability in mountain food systems.

Impacts of Climate Change on Food Systems

The rise in temperature in the HKH is higher than the global average. In the future, even if global warming is kept to 1.5°C, warming in the HKH is likely to be at least an additional 0.3°C higher and at least 0.7°C higher in the northwestern region.[6] An increase in temperature can potentially benefit high-mountain regions through an upward shift of crops such as bean and maize. However, issues such as land-use conflicts, pest-host interactions, and increased frequency of extreme climatic events can counteract these potential benefits.[7] Local studies have already revealed that the occurrence of climate-change-induced hazards (such as erratic rainfall, flood, drought, unexpected changes in temperature, pest attacks on crops, and livestock diseases) has increased in the HKH (Figure 1). The warming in mountains is likely to trigger a range of biophysical and socio-economic impacts, such as increased glacial melting, biodiversity loss, and less predictable water availability. All of these impacts are likely to affect food security and livelihoods in the HKH.[6]

In the region, climate change has both direct and indirect negative impacts on crop and livestock productivity and the overall livelihoods of the people.[4] Changes in temperature and precipitation patterns mainly result in an unstable water supply in agriculture and land degradation. Temperature rise is affecting glaciers in the western part of the HKH (i.e., Hunza and Chitral in Pakistan and Himachal Pradesh in India), where the surging of glaciers has led to water scarcity and the abandonment of hundreds of traditional irrigation systems (locally known as *kuhls* or *gols*).[8,9]

In the recent past, glacial lake outburst floods have induced a lot of damages to agriculture and infrastructure in the central

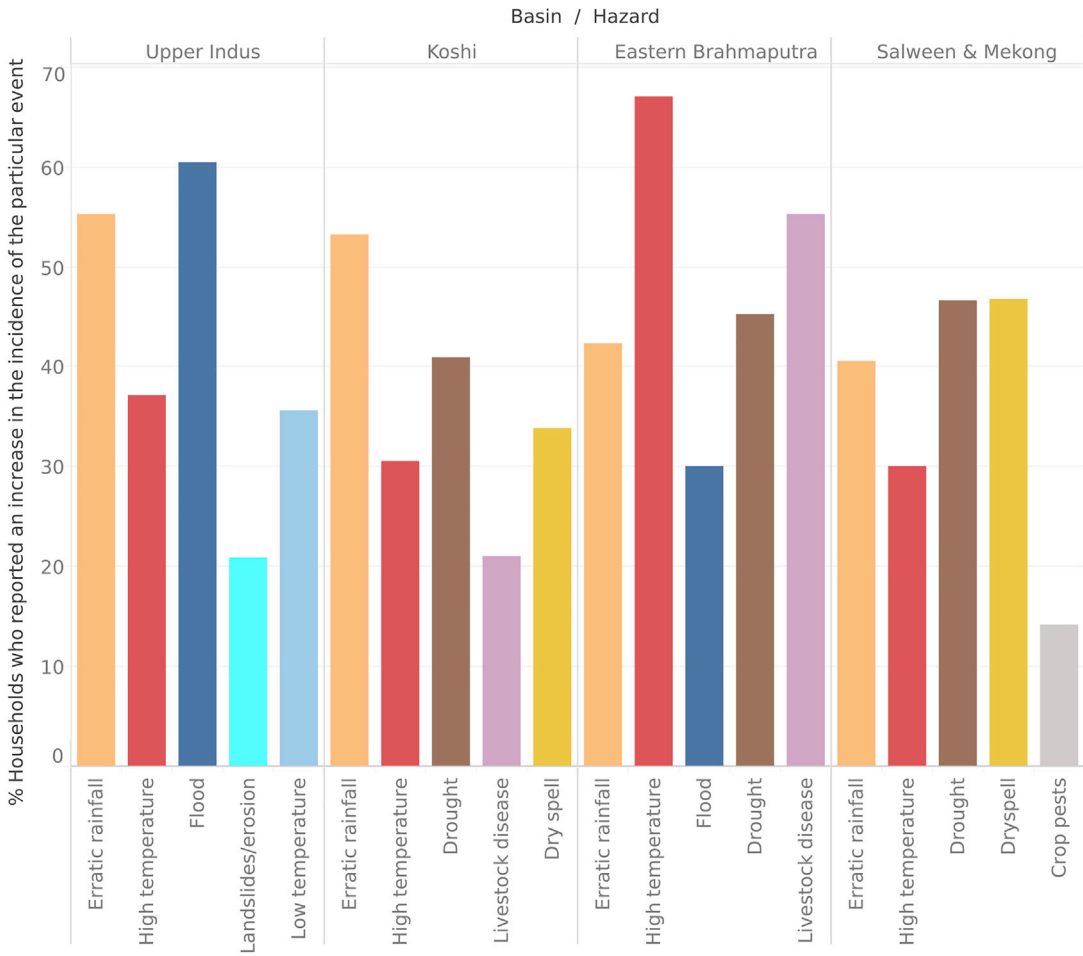

Figure 1. Local Perspective on Climate-Change-Induced Events and Hazards in the HKH

Figure 1 is based on the analysis of a household survey (n = 8,083) conducted in 2012 in four river basins of the HKH: Upper Indus (Pakistan), Koshi (Nepal), Eastern Brahmaputra (India), and Salween and Mekong (China). This survey, titled "Poverty and Vulnerability Assessment Tool," was established by the International Centre for Integrated Mountain Development. Only five main hazards and events, which are attributed to climate change by households, are presented here. The data represent household perception of the increase in hazards and events in 2012 compared with the situation 10 years ago (2002 or earlier).

and western parts of the HKH. Blocked or broken roads due to unexpected heavy snowfalls, landslides, and floods in mountains result in the physical isolation of local communities from other areas, leading to an unstable food supply for the local people in mountains, where local storage and food-processing facilities are inadequate. Likewise, droughts not only negatively affect the productivity of agriculture but also result in a rise in food prices and a consequent reduction in food consumption.[3] Frequent droughts are also resulting in an increase in the degradation of rangelands and pastures, leading to negative impacts on livestock productivity and the food security of pastoralist communities in mountain areas. Moreover, they are also likely to result in a decline in agrobiodiversity,[10] which can lead to a decline in dietary diversity and nutrition security in the mountains.[11] A prolonged drought from 1998 to 2002 in the Balochistan province of Pakistan resulted in serious water stress on agriculture. Drastic changes in the structure of plant communities in the degraded rangeland ecosystem, as well as shortages of water and fodder, led to the death of 1.76 million livestock and agricultural activities on around 1 million ha of cultivable land. Food prices rose, and the food security and livelihoods of nearly 2 million mountain people were affected, resulting in reduced food consumption and the migration of people to other areas.[12]

Declining Agrobiodiversity in Food Systems

Globally, existing food systems are dominated by a few crops, and production diversity is declining.[13] Three crops, namely, wheat, rice, and maize, account for more than half of the dietary energy supply in the world.[5] In the HKH, the decline in agrobiodiversity is high, and traditional nutritious food crops such as buckwheat, barley, millets, sorghum, oat, and beans are gradually disappearing from food systems entirely.[11] The share of traditional cereals in total cereal production is declining over time (Figure 2), which could also be considered a proxy indicator of a decline in agrobiodiversity. National data from Nepal show only a slight decline in the share of traditional crops (Figure 2), but in the country's high-altitude mountain districts (e.g., Humla and Jumla), the decline is very significant.[14]

Maintaining traditional crops and native livestock is key to improving

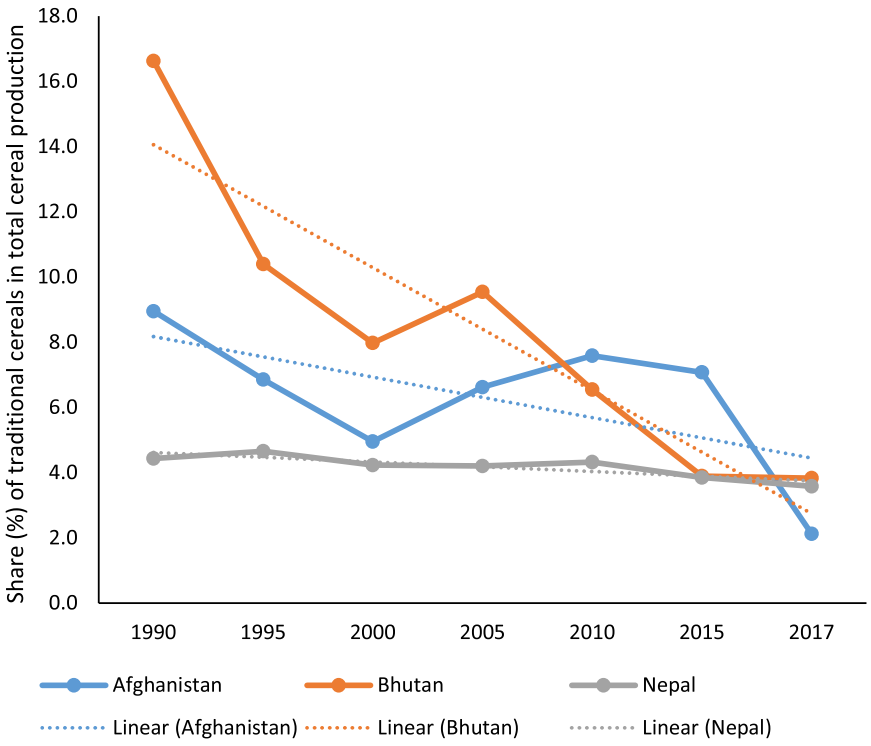

Figure 2. Declining Share of Traditional Cereals in Total Cereal Production in Three Countries

Data for only three countries—Nepal, Bhutan, and Afghanistan—were analyzed because almost the whole geographical area of these countries falls in the HKH. Cereals included wheat, rice, barley, maize, rye, oats, millets, sorghum, buckwheat, triticale, and cereals not specified elsewhere. Traditional cereals included barley, oats, millets, sorghum, and buckwheat. Source: analysis based on data from the FAO.[15]

agrobiodiversity, food and nutrition security, and reliance on the food system. These crops have high nutritive value and are key to coping with micronutrient deficiencies within the mountain population.[3] Some traditional crops, such as jammun and sea buckthorn, also have high medical importance. Similar to traditional crops, local breeds of poultry and livestock (e.g., sheep and yak) are also neglected and underutilized. Overall, the population of local breeds of livestock and poultry has decreased over time in mountains as a result of changing priorities for types of livestock based on productivity, as well as climate-induced degradation of rangelands and grasslands. In particular, the population of yak is in decline in India, Nepal, and Bhutan.[16]

Although the impact of climate change is undoubtedly important, it is also essential to understand non-climactic impacts on agrobiodiversity in the HKH. For instance, rapid population growth and increasing food demand alongside advances in agricultural research and governmental policies and subsidies have resulted in an increased cultivation of popular cereals (e.g., wheat, maize, and rice) and cash crops over traditional crops.[3] A shift from traditional to cash crops is also leading to an excessive use of inorganic inputs in mountain agriculture, posing serious challenges to the environment and sustainability.

A high outmigration rate is also indirectly affecting traditional crops and native livestock. Outmigrants, during their home visits, introduce new food items (e.g., instant food items) and recipes to the mountains, which, along with improved access to information technology and urban centers, is leading to a gradual change in dietary habits.[5,16] Consequently, in several parts of the HKH, traditional crops are now being considered by many to be the "food of the poor," and younger generations prefer popular cereals and instant food items. This has had many implications in terms of changes in food-production systems, including the replacement of traditional crops and native livestock with popular crops and improved breeds, respectively. Lack of knowledge about the importance of traditional crops and native livestock for agrobiodiversity and nutrition is also an important factor influencing food systems.[5]

Achieving Sustainability in Mountain Food Systems

To achieve Sustainable Development Goal 2 (Zero Hunger) in the HKH, it is important to improve sustainability in the food systems though tackling the dual challenge of climate change and agrobiodiversity loss.

To adapt to increasing climate risks, it is important to strengthen the regular agriculture advisory services, and a special effort should be made to establish mountain-specific climate services dealing with snow cover, permafrost, and glacier-related disasters. While following the federal governments' policies and provincial programmatic approach, local institutions should be independent in designing and developing context-specific, inclusive, and farmer-responsive advisory services. Such operational services can reduce the losses of agriculture, infrastructure, and other non-agricultural income activities. In agriculture, farmers need to adopt climate-resilient practices such as improved agrobiodiversity, soil and water conservation methods, and the introduction of new crop varieties that can tolerate water and temperature stresses. In addition, it is important to increase food procurement and storage capacity in the mountains to ensure systems and infrastructure that allow for durable food storage and far-reaching distribution systems. It will reduce mountain people's dependence on external food items and will avoid the risk of transitory food insecurity during hazards, e.g., landslides and floods, which mostly block connecting roads and break bridges.

Agrobiodiversity has traditionally served as insurance against pests, diseases, and climatic fluctuations and as a coping mechanism in times of scarcity.[17] Crop diversity, crop habitat diversity, and the assemblage of varieties of crops and livestock breeds are critical for maintaining stability in food systems.[18] Improving diversity in agriculture through the revival of traditional food crops and native livestock is key to improving all three aspects of sustainability—environmental, social, and economic factors—in

food systems. It is important to highlight that traditional crops should be reintegrated in food systems without replacing any other crop or livestock because existing agronomic crops, fruits, nuts, and medicinal plants are equally important to maintaining diversity in the food system. Reintegration of traditional crops could be ensured through the readjustment of area allocated to different crops.

As far as the environmental benefits of traditional crops are concerned, they require less water and fewer inputs than popular cereals and cash crops and can survive in harsh weather and marginal lands. For example, barley, with its short growing period, is cultivated in the high altitudes and cold climate of the Tibetan Plateau (China) and in Sindhupalchok (Nepal). Buckwheat is also commonly grown in the HKH region because it grows fast and suppresses weeds. Recently, experimental cultivation of quinoa in saline and marginal soils of Pakistan has shown that this crop can also produce comparable yields in stressful conditions. Moreover, most of the traditional crops are being cultivated without or with limited use of inorganic inputs in mountains. This implies that these are "socio-environmentally responsible crops" with far fewer impacts on soil health and the environment and higher benefits for food and nutrition security. In 2017, the FAO relabeled these crops as "future smart crops" in view of their importance for climate change resilience, agrobiodiversity, agriculture sustainability, and food and nutrition security.[11] If these crops, together with native livestock, are mainstreamed in institutional support systems (e.g., support prices, subsidies, and focused extension services), research, technology, value-chain development, and policies, they can also be a high-income source for mountain communities.

Last but not the least, both challenges—climate change and agrobiodiversity—are transboundary and require regional cooperation among countries through the sharing of data, scientific knowledge, and technology. The challenges cannot be tackled in isolation.

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