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Review

Tapping the Potential of Neglected and Underutilized Food Crops for Sustainable Nutrition Security in the Mountains of Pakistan and Nepal

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Abstract: Neglected and underutilized food crops (NUFCs) have high nutritional value, but their role in achieving nutrition security is not adequately understood, and they do not feature in food and nutrition policies and programs of the countries of the Hindu-Kush Himalayan (HKH) region. Drawing examples from Pakistan and Nepal, this study investigates the importance of NUFCs in achieving nutrition security in the mountains and identifies key underlying reasons for the decline in their cultivation and use. The study found that the prevalence of malnutrition is significantly higher in the mountains than nationally in both Pakistan and Nepal and identifies the decline in the cultivation and use of micronutrient-rich NUFCs as one of the key reasons for this. The deterioration of local food systems, changing food habits, lack of knowledge about the cultivation, use and nutritional value of NUFCs and lack of attention to NUFCs in programs and policies are the key reasons for the abandoning of NUFCs by mountain communities. There is an urgent need to mainstream these crops into national programs and policies and to integrate them into local food systems. This will not only improve the nutrition security of mountain areas, but also biodiversity and local mountain economies.

Keywords: neglected and underutilized food crops; micronutrients; nutrition security; policy options; Hindu-Kush Himalayan region

1. Introduction

Investing in nutrition security has many benefits for developing countries, because it contributes to the achievement of many other development goals related to agriculture, water, health, education, poverty alleviation and gender development. Three Sustainable Development Goals of the United Nations—Goal 2 (end hunger, achieve food security and improved nutrition and promote sustainable agriculture), Goal 3 (ensure healthy lives and promote wellbeing for all at all ages) and Goal 6 (ensure access to water and sanitation for all)—are directly related to nutrition security. Secure nutrition addresses not only the required level of calorie intake, but also the proper balance of food items in a households' food basket. Therefore, food patterns with a high diversity of food groups and a variety of items with a range of micro- and macro-nutrients are important to achieve nutrition security [1,2]. The impact of malnutrition is greater among the poor, women and children, leading to negative effects on immune functioning, cognitive development, child growth, reproductive performance and work productivity [3]. Micronutrient deficiencies also increase the general risk of infectious illness, as well as non-infectious diseases, such as malaria and pneumonia, and even diarrhea [4]. In the Hindu-Kush Himalayan (HKH) region, a substantial proportion of the population is facing malnutrition due to imbalances in dietary intake and the incidence of diseases related to the lack of one or more nutrients (e.g., protein, iodine, vitamins, calcium or iron) [5–7].

Nutrition is more important for mountain people in view of the nature of their work, the difficult topography in which they live and the required level of energy needed to perform their daily tasks. However, studies conducted in the countries of the HKH [5,8] have revealed that the prevalence of undernutrition is comparatively higher in mountain areas than nationally. The high prevalence of undernutrition in the mountains is attributed to poverty, high illiteracy rates among mothers, dietary deficiencies, poor maternal and child health and nutrition, high morbidity rates and the low micronutrient (especially iodine and zinc) content of food [5].

Of the thousands of known plant species, only 120 are cultivated for human food, and only nine supply over 75% of the global plant-derived energy. Three crops, namely, wheat, rice and maize, account for more than half of dietary energy supply [9,10]. This implies that more than one hundred edible plant species are neglected or underutilized for their nutritional value. In the HKH region, mountains are agro-ecologically suitable for the cultivation of traditional food crops, such as barley, millets, sorghum, buckwheat, beans, gram and other pulses, taro, yam, amala and jammun, a vast range of wild vegetables and fruit and medicinal plants [11,12], which are important sources of micronutrients [13]. However, agricultural intensification, which is increasingly relying on a narrow range of crops [14], has resulted in a decline in the cultivation of traditional food crops and the underutilization of this nutritionally-valuable food source. This has led to low dietary diversity and, ultimately, a higher prevalence of malnutrition [12] in the mountains, and globally. In the HKH region, in the past, household food baskets consisted of many different edible plant species. However, due to changes in local food systems, food habits, policy priorities and several other factors, today, traditional crops are largely neglected and underutilized. The neglected and underutilized food crops (NUFCs) in the HKH are mainly millets, sorghum, buckwheat, barley, beans, black gram, horse crop, taro, yam, amala and jammun [11,12].

NUFCs, which are part of a larger biodiversity portfolio, were once more popular, but today are neglected by the people [15]. These crops continue to be grown, managed and collected in marginal localities because of their usefulness for local populations [16]. In recent years, it has been realized that NUFCs may play a vital role in food and nutrition security [17–19], as well as income improvement [20–24]. Moreover, the diversification of agricultural production systems through the promotion of NUFCs offers opportunities for strengthening the adaption, mitigation and resilience of both the natural and socioeconomic systems to climate change [25], particularly in mountains. NUFCs are more resilient to climate stresses than advanced cereals and cash crops [26,27]. Chivenge et al. [27] reported in their study from Sub-Saharan Africa that pearl millet, amaranth and beans are more drought tolerant compared to rice, wheat and maize. In the Gatlang area of Rasuwa district of Nepal, NUFCs growers reported that they preferred to cultivate local beans, barley, millets and local maize because they are more tolerant to water stress and extremely cold conditions [28]. Advanced cereals and cash crops are often more input intensive and more susceptible to crop failure, seasonality, price shocks and market forces than NUFCs and, therefore, constitute an unacceptable risk for many poor farmers [29–31]. The genetic resources of these crops may be vital for sustaining agriculture [12] and adapting to climate change, because many of these species are well adapted to stressful environmental conditions [12]. 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 [32]. Recently, experimental cultivation of quinoa in saline and marginal soils of Pakistan has shown that this crop may also produce comparable yield in stressful conditions [33]. Some successful evidence is also found from other mountain regions. For example, emmer performed very well in poor soils in the mountains of Turkey [34].

Some NUFCs also have high medical importance. For instance, the people in remote areas of the HKH region have been using jammun to treat diabetes. In the Gilgit-Baltistan province of Pakistan, in the recent past, the local people have realized the importance of sea-buckthorn for nutritional and medicinal purposes and have expanded the cultivation of this crop. Some NGOs have

helped the local community to develop the value chain of this crop and trained the local women to prepare a range of products [35]. Similarly, local NUFCs are used by the people living in the Pamir Mountains of Afghanistan and Tajikistan as a principal remedy in treating sicknesses and ailments. Villagers identified over 58 cultivated and non-cultivated plants and described 310 distinct uses within 63 categories of treatment and prevention [36].

NUFCs have high nutritional value, but their role in the nutrition security of mountain people is not adequately understood, and they have not been mainstreamed into existing policies and programs on nutrition. For example, emmer is a typical example of NUFCs from mountain areas of Turkey. Despite its high importance for food and nutrition security, this crop is still neglected and underutilized due to lack of market opportunities, consumers' demand and policy focus [34]. The HKH region is not an exception where NUFCs are neither mainstreamed in policies and programs, nor adequately featured in local production systems. The present study has been undertaken to investigate the role of NUFCs in the nutrition security of mountain communities, drawing examples from two HKH countries: Pakistan and Nepal. Although NUFCs include several traditional cereals, fruits, legumes and vegetables, this study focuses only on selected traditional cereals, pseudo cereals and legumes.

The next section (Section 2) discusses the methodology followed in this study. Section 3 discusses the status of nutrition security in the mountains of Pakistan and Nepal, followed by Section 4 on the nutritional importance of NUFCs. Section 5 examines the production trends of NUFCs, followed by Section 6 on key challenges to production. Section 7 presents a framework for mainstreaming NUFCs to achieve nutrition security in the mountains, followed by a brief conclusion in Section 8. The proposed strategic framework mainly suggests policy instruments to revive NUFCs in the local food production systems. It also suggests policy instruments to increase the demand and consumption of NUFCs in the mountain areas.

2. Methodology

This study is mainly based on secondary data that were collected from relevant research articles, reports and national databases of Pakistan and Nepal. In the case of Pakistan, data of NUFCs were procured from 'Agricultural Statistics of Pakistan 2011–2012' [37] published by the Ministry of National Food Security and Research. From this official report, average production of NUFCs was collected for four time periods, e.g., 1993–1994 to 1994–1995, 1995–1996 to 1999–2000, 2000–2001 to 2004–2005 and 2005–2006 to 2009–2010. For Nepal, production data of NUFCs (from 2007–2014) were procured from a national report 'Statistical Information on Nepalese Agriculture 2013–2014' [38] published by the Ministry of Agricultural Development. Some additional analyses were also conducted for Nepal to investigate the per capita production of NUFCs. In this regard, population data for the years 1981, 1991, 2001 and 2011 were collected from an official report 'National Population and Housing Census 2011' [39] published by National Planning Commission, to project the population for the years 2012–2014. The linear growth method (Equation (1)) was used to project the populations.

$$P_f = P_b + K \times t \tag{1}$$

where: P_f = future projected population, P_b = population of base year (start of projection), K = growth rate, t = number of years projected into the future.

Growth rate 'K' and number of years 't' can be calculated using the equations below.

$$K = \frac{(P_b - P_0)}{(t_b - t_0)} \tag{2}$$

$$t = (t_f - t_b) \tag{3}$$

where: P_b = population of base year, P_0 = population of initial year (in the applicable linear growth period), t_b = base year (start of projection), t_0 = initial year (in the applicable linear growth period), t_f = future year (end of projection).

For this study, it was planned to select at least five NUFCs from each country, e.g., Nepal and Pakistan. For Nepal, millets (cereals), buckwheat (pseudo-cereal), barley (cereal), black gram (legume) and horse gram (legume) were selected from nationally-identified list of NUFCs by Nepal Agricultural Research Council. However, In the case of Pakistan, only three neglected and underutilized cereals, e.g., barley, millets and sorghum, were selected based on the discussion with the National Agricultural Research Centre (NARC), Islamabad. Pakistan has not officially identified a list of NUFCs. However, based on the data of production and consumption patterns in the past and present, experts from NARC suggested to consider millets, barley and sorghum for this study. These three crops were historically an integral part of household food baskets in the mountain areas of Pakistan, but now, they are rarely found in production systems and consumption patterns.

3. Nutrition Security in the Mountains

The prevalence of food and nutrition insecurity is higher in the mountains than in the plains. In Pakistan, for instance, food insecurity in mountain provinces, such as Balochistan and Khyber Pakhtunkhwa, is higher than the national average (Table 1). In Balochistan, approximately two-thirds of the population are food insecure. Likewise, the percentage of micronutrient deficient women (aged 15–49) is also comparatively higher in the mountains than nationally, as evidenced by the high percentage of calcium-deficient women in Balochistan and Khyber Pakhtunkhwa. The prevalence of stunted, wasted and underweight children (aged < 5 year) in Balochistan is 82%, 13% and 37%, respectively, which is significantly higher than national averages (Table 1). In Khyber Pakhtunkhwa, the prevalence of calcium deficiency in pregnant women is less compared to non-pregnant women due to micronutrient supplementation programs implemented for pregnant women in the country [5]. This program has not shown considerable success in Balochistan due to cultural constrains. Compared to Balochistan and the national average, NUFC intake in Khyber Pakhtunkhwa is relatively better (see Section 5). This may also be attributed to the low prevalence of stunting and underweight children in Khyber Pakhtunkhwa, in addition to several other socioeconomic factors.

Table 1. Food and nutrition security in the mountains of Pakistan.

Indicator		National Average (%)	Mountain Provinces	
			Balochistan (%)	Khyber Pakhtunkhwa (%)
Prevalence of food insecurity (%) *		49	61	56
% of women (aged 15–49 year) ** with calcium deficiency	Non-pregnant women	51	60	71
	Pregnant women	58	63	61
% of children (aged < 5 year) with growth problems ***	Stunting [1]	44.4	81.9	41.3
	Wasting [2]	10.7	13.2	11.7
	Underweight [3]	29.4	37.4	25.3

[1] Height-for-age: children under age 5 years <−2 SD from the international reference median value; [2] weight-for-height: children under age 5 years <−2 SD from the international reference median value; [3] weight-for-age: children under age 5 years <−2 SD from the international reference median; Note: Out of a total of eight administrative units (provinces) in Pakistan (including the capital territory), five are mountainous. In this table, only two provinces are taken as examples, Balochistan and Khyber Pakhtunkhwa. Sources: * [5], *** [6], ** [40].

Similarly, in Nepal, mountain areas face higher food and nutrition insecurity than the country as a whole. In mountain areas, almost 60% of households are food insecure. Moreover, the prevalence of stunting and being underweight in children (aged < 5 year) is nearly 53% and 36%, respectively, which is significantly higher than the national averages of 41% and 29%, respectively (Table 2).

Table 2. Food and nutrition security in the mountains of Nepal.

Indicator	National Average (%)	Mountains (%)	Hills (%)
Food insecure households (%)	50.8	59.5	52.8
Prevalence of underweight women (aged 15–49 years)	18.2	16.5	12.4
Stunting * (%)	40.5	52.9	42.1
Wasting ** (%)	10.9	10.9	10.6
Underweight *** (%)	28.8	35.9	26.6

* Height-for-age: children under age 5 years <−2 SD from the international reference median value; ** weight-for-height: children under age 5 years <−2 SD from the international reference median value; *** weight-for-age: children under age 5 years <−2 SD from the international reference median value; Source: [7].

4. Nutritional Importance of NUFCs

NUFCs are important for ensuring an adequate supply of micronutrients to the human body, the deficiency of which may lead to stunting, wasting and being underweight, as well as several other health problems [5]. Several NUFCs that were an integral part of household food baskets in the mountain areas in the past are gradually being replaced by advanced cereals, such as wheat, rice and maize. The survival of some NUFCs in mountain food systems in the HKH—particularly *Amaranthus* (*Amaranthus caudatus*), naked barley (*Hordeum vulgare*), black gram (*Vigna radiate*), horse crop (*Macrotyloma uniflorum*), olarum (*Amorphophallus campanulatus*), yam (*Dioscorea spp.*), rayo (*Brassica juncea*), sesame (*Sesamum indicum*), niger (*Guizotia abyssinica*), kaphal (*Myrica esculenta*), chiuri (*Aesandra butyracea*), amala (*Phyllanthus emblica*), pumello (*Citrus maxima*) and jammun (*Syzygium cumini*)—is under threat [12]. These crops are rich in micronutrients and need to be conserved in mountain food systems [41].

To examine the difference between the nutritional value of advanced cereals and NUFCs, data for some selected crops are presented in Table 3. NUFCs are comparable to advanced cereals in terms of dietary energy and protein content, but are also rich in micronutrients (Table 3). For instance, pearl millet has a higher content of micronutrients (such as calcium, iron, zinc, riboflavin and folic acid) than rice or maize. Pearl millet also has a higher content of micronutrients (excluding calcium) than wheat. This implies that, in the past, food consumption was much more diverse and nutritionally rich. The argument is not to fully replace advanced cereals with NUFCs in consumption patterns, but to realize the importance of NUFCs for nutrition and to include them sufficiently in consumption patterns.

Table 3. Nutritional value of neglected and underutilized food crops: some examples.

Nutrient	Some Examples of Traditional Food Crops (Content/100 g)							Advanced Cereals (Content/100 g)		
	Pearl Millet	Sorghum	Finger Millet	Foxtail Millet	Proso Millet	Barnyard Millet	Kodo Millet	Rice (Milled)	Maize	Wheat Flour
Energy (kcal)	361	349	328	331	341	397	309	345	342	346
Protein (g)	11.6	10.4	7.3	12.3	7.7	6.2	8.3	6.8	11.1	12.1
Fat (g)	5.0	1.9	1.3	4.3	4.7	2.2	1.4	0.4	3.6	1.7
Calcium (mg)	42.0	25.0	344	31.0	17.0	20.0	27.0	10.0	10.0	48.0
Iron (mg)	8.0	4.1	3.9	2.8	9.3	5.0	0.5	3.2	2.3	4.9
Zinc (mg)	3.1	1.6	2.3	2.4	3.7	3.0	0.7	1.4	2.8	2.2
Thiamine (mg)	0.33	0.37	0.42	0.59	0.21	0.33	0.33	0.06	0.42	0.49
Riboflavin (mg)	0.25	0.13	0.19	0.11	0.01	0.10	0.09	0.06	0.10	0.17
Folic acid (mg)	45.5	20	18.3	15.0	9.0	-	23.1	8.0	20	36.6
Fiber (g)	1.2	1.6	3.6	8.0	7.6	9.8	9.0	0.2	2.7	1.2

Source: [13].

5. Production Trends and Consumption

The production of NUFCs in mountain areas has decreased over time. For instance, in the mid-1990s, Khyber Pakhtunkhwa and Balochistan provinces of Pakistan contributed 72% to national production of barley, but by the end of 2010, this contribution had dropped to only 56% [37].

In Khyber Pakhtunkhwa, the average production of barley was more than 60,000 metric tons in the mid-1990s. This gradually declined to only 30,000 metric tons by 2010 (Figure 1). Likewise, in Balochistan, the average production of barley declined from 51,000 metric tons in the mid-1990s to nearly 16,000 metric tons in 2010 (Figure 1).

In Khyber Pakhtunkhwa, the average production of sorghum and millets has also declined consistently. Compared to the mid-1990s, the average production of sorghum and millets had declined by nearly 62% and 67%, respectively, by 2010 (Figure 2).

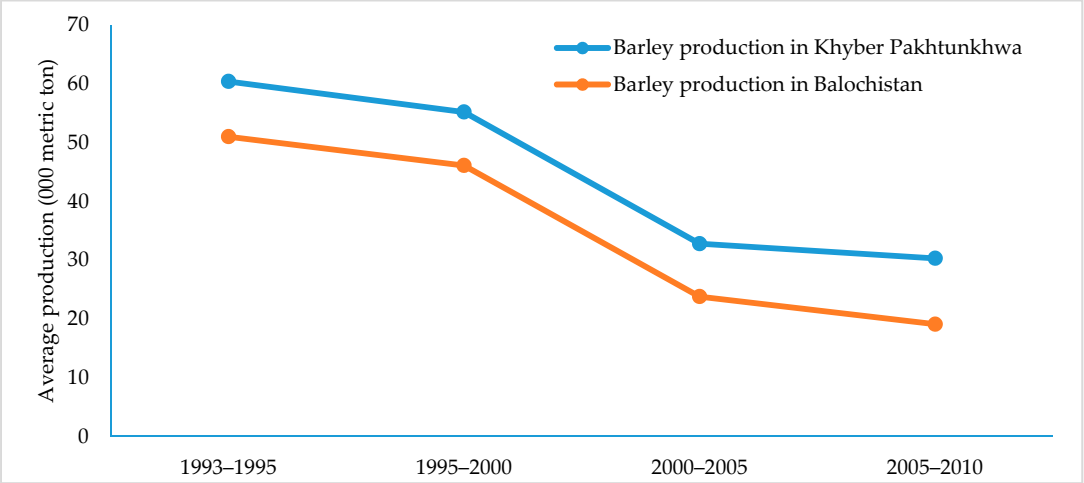

Figure 1. Trends in barley production in Khyber Pakhtunkhwa and Balochistan, Pakistan. Source: [37].

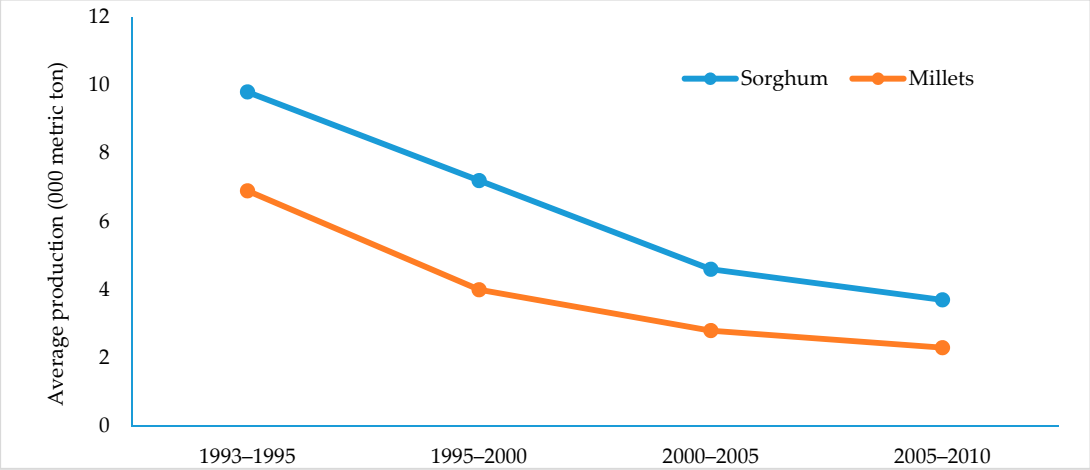

Figure 2. Trends in sorghum and millets production in Khyber Pakhtunkhwa, Pakistan. Source: [37].

In Balochistan, the average production of millets and sorghum declined from the mid-1990s–2005. However, from 2005 to 2010, it showed a slight increase. Overall, the average production of sorghum declined by 39% between the mid-1990s and 2010 (Figure 3). National-level statistics reveal that the average production of sorghum and barley has declined by 31% and 84%, between the mid-1990s and 2010; source: [37]. As mountain areas are the main contributor to the national production of these crops, the decline in their production in the mountains is one of the reasons for their decline at the national level.

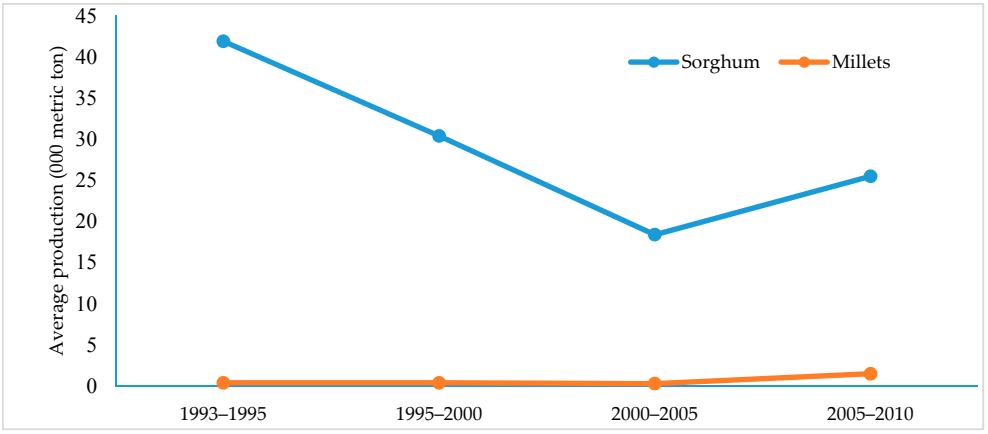

Figure 3. Trends in sorghum and millets production in Balochistan, Pakistan. Source: [37].

In Nepal, the production of NUFCs, in absolute terms, has shown a moderate increase over the years (Table 4). However, in terms of per capita production, millets and black gram have declined (Figures 4 and 5). The production of some crops, such as horse gram and buckwheat, has not shown a significant fluctuation between 2007 and 2014. Only the production of barley has increased per capita until 2012 followed by a slight decline in 2014 (Figure 5).

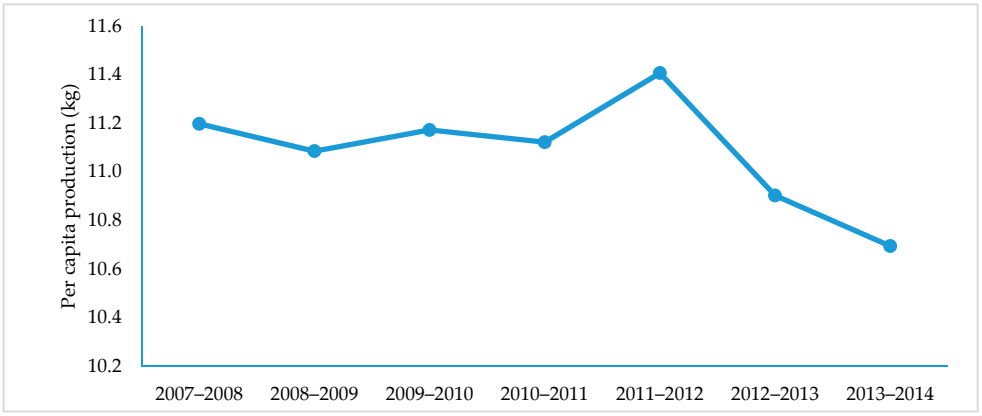

Figure 4. Trends in production (per capita) of millets in Nepal. Source: [38].

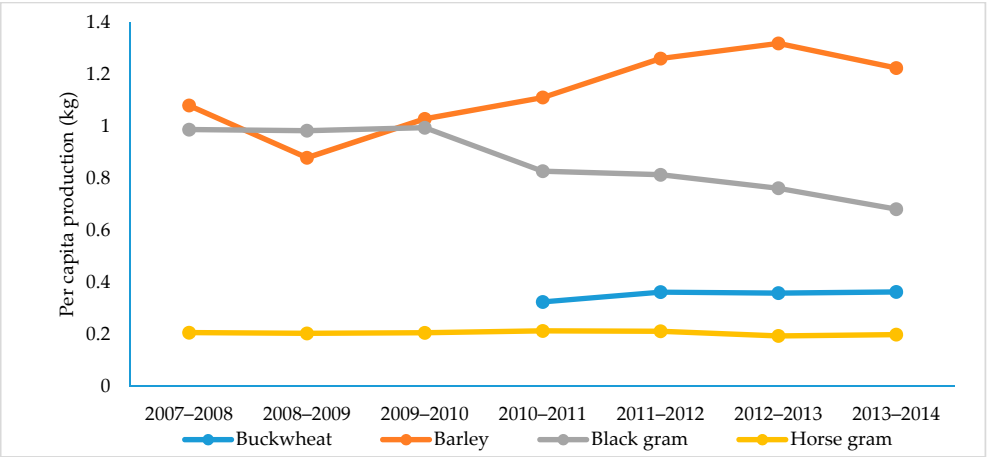

Figure 5. Trends in production (per capita) of some neglected and underutilized food crops (NUFCs) in Nepal. Source: [38].

Table 4. Production trends of NUFCS and advanced cereals in Nepal.

Year	Millets		Buckwheat		Barley		Black Gram		Horse Gram		Wheat		Rice		Maize	
	NP (000 MT)	PCP (kg)	NP (000 MT)	PCP (kg)	NP (000 MT)	PCP (kg)	NP (000 MT)	PCP (kg)	NP (000 MT)	PCP (kg)	NP (000 MT)	PCP (kg)	NP (000 MT)	PCP (kg)	NP (000 MT)	PCP (kg)
2007/2008	291	11.198	NA	NA	28	1.080	26	0.988	5	0.207	1572	60	4299	165	1879	72
2008/2009	293	11.085	NA	NA	23	0.880	26	0.983	5	0.204	1344	51	4524	171	1931	73
2009/2010	299	11.172	NA	NA	28	1.029	27	0.995	6	0.206	1556	58	4024	150	1855	69
2010/2011	303	11.122	8841	0.325	30	1.111	22	0.828	6	0.213	1746	64	4460	164	2067	76
2011/2012	315	11.406	10,021	0.363	35	1.261	22	0.814	6	0.212	1846	67	5072	184	2179	79
2012/2013	306	10.903	10,056	0.359	37	1.319	21	0.762	5	0.194	1882	67	4504	161	1999	71
2013/2014	304	10.695	10,335	0.363	35	1.225	19	0.682	6	0.199	1883	66	5047	177	2283	80

Notes: The population for particular years was projected using the linear growth technique to estimate per capita production of NUFCs. NP = national production; PCP = per capita production; MT = metric ton (metric ton = tonne); NA = not available. Source: [38].

Compared to wheat, rice and maize, per capita production of NUFCs is extremely low in Nepal. For example, the per capita production of wheat, rice and maize was 66 kg, 177 kg and 80 kg, respectively, in 2013–2014, which is much higher than the production of NUFCs in the same year (Table 4). This implies that NUFCs are not preferred by farmers or policy makers as an option for the nutrition security and livelihoods of local people.

In addition to production trends, it is also important to investigate the consumption patterns of households to assess the contribution of NUFCs in food intake. In Pakistan, rice and wheat contribute 53% to per capita per day calorie intake. NUFCs, such as millets, barley and sorghum, contribute only 0.22% to per day per capita calorie intake. In Balochistan and Khyber Pakhtunkhwa, wheat and rice (collectively) contribute respectively 59% and 51% to calorie intake. However, NUFCs such as sorghum, barley and millets (collectively) contribute only 0.23% and 1.63% to calorie intake respectively in Balochistan and Khyber Pakhtunkhwa [42]. In Nepal, NUFCs, such as millets, barley, buckwheat, black gram, lentils, red gram, horse gram and beans, contribute nearly 8% to annual per capita food consumption, whereas rice, wheat and maize contribute nearly 62%. If we consider only millets, barley, buckwheat, black gram and horse gram, the contribution remains only 3.84% [43]. Consumption statistics show that intake of NUFCs in both Nepal and Pakistan is very small compared to advanced cereals. However, the contribution in Nepal is slightly better than Pakistan. This may be one of the reasons for an increase in absolute production of NUFCs in Nepal.

6. Challenges to Production of NUFCs

Despite the huge potential of NUFCs for nutrition security in the mountains, these crops are not considered as primary food crops by farmers and policy makers. This section looks at the key challenges that limit the cultivation and consumption of these crops.

6.1. Deteriorating Local Food Systems and Agro-Diversity

Mountain farmers are gradually switching to high-yielding staple and cash crops, resulting in the abandoning or limited cultivation of NUFCs [44,45]. Population growth, changing demand for food and low market value are some of the main factors triggering the preference for advanced cereals and cash crops. Although the population has grown and food demand has increased in mountain areas, agricultural productivity has not increased significantly due to the degradation of resources [35,46]. Global forecasts of population growth and economic development also indicate that there will be substantial increases in food demand in coming decades [47]. In this context, governments and farmers prefer high-yielding varieties of advanced crops. Importantly, market demand for advanced cereals is increasing compared to demand for NUFCs. Sometimes, farmers receive advance payments from intermediaries for producing advanced cereals and cash crops, which has resulted in them abandoning the cultivation of NUFCs [48]. Reduced cultivation of NUFCs has led to a decline in the diversity of agriculture ecosystems and dietary patterns [49], particularly in the HKH region.

6.2. Changing Food Habits

Acceptability of NUFCs by poor and rich people is different in the HKH region. In the region, the magnitude of poverty is comparatively higher than the plains [50]. Poor people have a very limited choice of food items due to their low income levels, leading to higher food and nutrition insecurity [51]. A case study conducted in the Kailali district of Nepal revealed that over 60% of mothers reported an inability to feed their children nutritious foods, such as eggs, milk and meat, because they could not afford these items [52]. NUFCs can play a vital role to improve nutrition security of mountain communities, particularly the poor people, because these crops are comparatively less expensive, rich in micronutrients and good alternatives of expensive food items. For instance, legumes are considered as a good protein source for vegetarians, and the poor who cannot afford to purchase meat.

Among the households with better income and living standards, acceptability for NUFCs had reduced, and younger generations prefer advanced cereals and instant food items. This has had many

implications in terms of changes in food production systems including the replacement of NUFCs with advanced food crops and instant food items. There are many factors that influence the consumption behavior of people, particularly youth. However, globalization, changing lifestyles and increased per capita income are the most prominent [53].

Furthermore, NUFCs are considered by many to be the 'food of the poor' [44,48]. A study conducted in Nepal revealed that traditionally-grown finger millet was considered a low-status food and consumed mainly by poor people. Consequently, instead of food, it was used as a raw material to ferment a locally-produced alcohol [48]. Shively and Thapa [54] also found that NUFCs, particular coarse rice, are the main food for poor households. In the mountain areas of Pakistan, wheat and fine rice have largely replaced traditional cereals [55]. Changing food habits are resulting in higher demand for advanced cereals and other food crops, not only in the mountains, but also in other areas. This is, ultimately, encouraging farmers to replace NUFCs with advanced food crops. In some regions of the Himalayas, the area under NUFCs has gradually decreased in favor of cash crops [38] and advanced cereals.

6.3. Lack of Nutritional Knowledge

Lack of knowledge about the cultivation of NUFCs and their use and nutritional value is another reason for the change in food habits and production systems. Indigenous knowledge is vital to the conservation of most NUFCs and agricultural ecosystems [27]. Due to the loss of indigenous knowledge, the current generation of mountain farmers is not properly aware of how to cultivate NUFCs and their role in agro-diversity. Similarly, regarding nutritional value, consumers and farmers are not aware that NUFCs are strong contributors to nutrition security [56,57], and that hidden hunger (deficiencies of micronutrients) may be eradicated through increased consumption of these micronutrient-rich crops. Furthermore, nutrition policies and programs have not focused on creating awareness among people (particularly mothers) about the importance of dietary diversity and the inclusion of NUFCs in their food basket. Within households, a mother's nutritional knowledge is very important for keeping a balance in the dietary patterns of the whole family, particularly for herself and her children [52].

6.4. Policy Constraints

The current international policy and legal frameworks on biodiversity and plant genetic resources have so far provided limited stimulus and funding for the conservation and sustainable use of the genetic resources of NUFCs [58]. Therefore, the protection and promotion of these traditional crops is not among the priorities of most governments [59]. Strategies for the promotion and support of NUFCs are almost entirely missing in the existing food and nutrition security policies and programs of HKH countries. Furthermore, there is no institutional mechanism to help local communities to realize and use the benefits from local agrobiodiversity or to provide market incentives for producers of NUFCs. Policies regarding food pricing or farm subsidies do not take into account traditional crops, and trade and market policies rarely consider the nutritional and ecological value of these crops [26,60]. The Food and Agriculture Organization's (FAO's) Global Plan of Action for Plant Genetic Resources for Food and Agriculture [9] emphasizes the importance of neglected and underutilized crops. However, NUFCs have still not been adequately mainstreamed in the global food and nutrition security agenda, which is resulting in negligible demand for these crops in global and national markets [60]. If there are no supporting polices and if there is not a good market (value and demand) for NFUCs, farmers, particularly mountain famers who generally have very small landholdings, will ultimately give up cultivating traditional crops, which is what is actually happening in the HKH region.

7. A Framework for Mainstreaming NUFCs for Sustainable Nutrition Security

NUFCs can make a significant contribution to sustainable nutrition security in mountains if they are mainstreamed into agriculture, food and nutrition security policies and programs and integrated

into local food systems. NUFCs have high potential to improve rural economics and are also climate smart due to less requirement of inputs and high resilience to water and heat stresses. Moreover, these are also socially and culturally acceptable due to their presence in local food production systems and consumption patterns over generations. In this era of commercialization, the integration of NUFCs into local food systems is not so simple due to farmers' preference for high-value cash crops in response to market demand and the changing food habits of consumers (from local nutrition-rich food items to advanced crops and cereals and processed instant foods). There is a dire need to create an enabling environment in the mountains through policy instruments (Table 5) so that farmers and consumers may resume the cultivation and consumption of NUFCs.

The most important step in supporting the integration of NUFCs into local food systems is to mainstream NUFCs into agriculture, food and nutrition security policies and programs. NFUCs should be given equal importance as cereals, such as rice, wheat and maize, in national policies and programs [49].

Another important step is to document and promote existing indigenous knowledge and techniques to support the resurrection of NUFCs in the mountains (Table 5). Decades ago, mountain farmers used to cultivate these crops and had good knowledge of their nutritional value. They used indigenous techniques to store, cook and process these crops into delicious dishes. This knowledge must be captured before it is lost.

The availability (and adequacy) of germplasm is also a problem in the mountains, because most farmers have given up the cultivation of NUFCs and, therefore, do not have seed stock. However, there are some small pockets where farmers still cultivate these crops. An adequate supply of seeds and guidelines on production techniques can be provided to farmers through agricultural extension services.

In addition to the supply of germplasm, it is also important to provide incentives to farmers in the form of subsidized inputs (mainly organic in nature) and mechanisms to support the price of NUFCs, at least for an initial 4–5 years. The provision of incentives will create interest among farmers in cultivating NUFCs.

Moreover, institutional mechanisms focusing on market facilities, storage services, extension services, credit and the use of ICTs are equally important in creating interest among mountain farmers in the cultivation of NUFCs (Table 5).

To improve market demand for NFUCs, there is a need to create awareness among mountain people, particularly mothers and youth, about the nutritional value of NUFCs (Table 5). This awareness may be created through media campaigns and course content in schools. Mothers should be educated to include food dishes prepared from NUFCs in the diet of their families. There is some evidence (from Nairobi, Kenya) that the demand for finger millet among urban households increased significantly due to awareness of the nutritional value of finger millet and the importance of healthy eating [61,62]. This increase in demand has opened new marketing opportunities for finger millet in Kenya, resulting in higher prices of this traditional crop in Kenya than prices for maize or other cereals [62]. It is expected that these price incentives will motivate Kenyan farmers to expand their cultivation of finger millet. A similar kind of awareness about nutritional value for consumption of NUFCs is required in the HKH region to create demand in the public and price incentives for farmers.

Supporting local food chains and establishing a processing industry for NFUCs are vital to improve local demand and improve opportunities for farmers to increase income (Table 5). Ultimately, supporting local food chains and processing will improve the interest of farmers in cultivating these indigenous crops, which have the potential to be profitable cash crops [61]. For consumers, supporting the local food industry will result in an increased range of available food products (improved food diversity) [63], which may turn out to be good substitutes for unhealthy instant food items. In recent years, increased dependence on external food crops and processed snacks and drinks, rather than NUFCs, has made mountain people more vulnerable to food and nutrition insecurity. Price shocks in food supplying areas and natural disasters (e.g., floods and landslides) can restrict food supply and

hike prices in mountain areas. Strengthening local food systems by promoting NUFCs will improve the stability of local food supplies and reduce dependency on external food items. Tapping the potential of NUFCs will also reduce the chances of outmigration from mountain areas as it will increase local employment opportunities due to the establishment of local food value chains and a local food processing industry. The potential for food exports from mountains to other areas will increase with the cultivation of NFUCs, contributing to mountain economies. In India, a holistic approach used to mainstream NUFCs, such as finger millet, little millet, foxtail millet and barnyard millet, revealed that these crops can play a strategic role in improving many dimensions of livelihoods. In this holistic value chain approach, special attention was devoted to promote the networking and collaboration among partners with complementary skills [64]. Likewise, In Bolivia and Peru, a holistic and innovative value chain framework linking the aspects of genetic diversity, selection, cultivation, harvest, value addition, marketing and final use of Andean grains was used to achieve the goals of improved conservation, better incomes, improved nutrition and strengthened livelihood resilience [65].

NUFCs may also be linked with tourism in mountain areas. Local food systems with higher diversity may also be promoted to attract tourists from other regions and countries. In tourism polices and guidelines, local hotels and resorts may be guided to include food dishes prepared from NUFCs on their menus. In the Rasuwa district of Nepal, farmers in the high altitude tourist areas, e.g., Gatlang and Grey, cultivate NUFCs, such as millets, local sweet maize, barley and local beans, and sell to local resorts and hotels at very good prices. Almost all of these local resorts and hotels in Gatlang, Grey and adjoining areas (Goljung, Syabrubesi and Chilime) offer food dishes prepared from these traditional food crops [28]. It has not only improved farmers' income, but also promoted these crops among tourists coming from diverse areas of Nepal and other countries. Moreover, there is huge potential to link NUFCs with school feeding programs. Governments may establish NUFCs procurement centers in the producing areas to supply food items prepared from NUFCs for school feeding programs. It will benefit both producers and school children to improve respectively their income and nutrition status. Padulosi et al. [65] also suggested the inclusion of NUFCs in school feeding programs in Bolivia and Peru. They promoted Andean grains and proposed the development of innovative food products and inclusion in school meal programs.

The integration of NUFCs into local food systems will also yield some auxiliary benefits for local ecosystems and economies. The cultivation of NUFCs can improve biodiversity and the environment [66]. The genetic resources contained in NUFCs are said to be vital for sustainable agriculture and adaptation to climate change [26,67]. Most traditional crops do not require high agricultural inputs and can be successfully grown on marginal, degraded or waste land with minimal inputs and a low level of investment [66].

Table 5. NUFCs for sustainable nutrition security in mountains: a suggested framework.

Creating an Enabling Environment (Policy Steps)	Suggested Option	Contribution of NUFCs to Strengthening Food Security Dimensions and Health		Contribution to Nutrition Security	Auxiliary Benefits
Mainstream NFUCs into national and sub-national policies and programs Document and promote the use of existing indigenous knowledge on the cultivation and utilization of NUFCs Ensure the availability of germplasm for NFUCs Create interest in cultivating NFUCs among farmers through incentives Strengthen institutional mechanisms (market facilities, extension services, credit and ICTs) Create awareness among people about the nutritional value of NUFCs Support local food value chains and establish a local food processing industry for NUFCs Link NUFCs with tourism (guide local hotels/resorts in mountain areas to include NFUCs on their menus) Link NUFCs with school feeding programs	Integrate NUFCs in local food systems	Food availability	Locally increased supply of food Improved diversity in available food	Reduced chances of growth problems in children (aged < 5 years), e.g., stunting, wasting and underweight Reduced prevalence of micronutrient deficiencies and anemia in children and women Reduced prevalence of underweight women (aged 15–49 years) Expected reduction in number of individuals with low body mass index	Improved biodiversity in mountains Reduced agricultural investment needed Increased employment opportunities in mountains may lead to reduced outmigration rate Increased opportunities for ecotourism Improved odds of exporting food products (prepared from NUFCs) from mountains to other areas, leading to improved income in mountain regions
		Food accessibility	Improved income for farmers Improved local income opportunities if local food processing industry is established Improved physical access to food due to local production of diverse foods		
		Food utilization and health	Improved diversity in food intake Improved intake of micronutrients, conducive to better health Reduced health hazards (NUFCs require less chemical fertilizers and pesticides)		
		Risks and uncertainties	NUFCs are highly climate resilient No risk of supply being cut due to natural hazards and economic factors because NUFCs are locally produced		

8. Conclusions

The Hindu-Kush Himalayan (HKH) region is agro-ecologically suitable for the cultivation of traditional food crops, such as barley, millet, sorghum, buckwheat, wild vegetables and fruit and medicinal plants. These traditional crops have been an integral part of the food basket of mountain households for hundreds years. However, the cultivation and consumption of traditional food crops has decreased over time. Today, three crops—wheat, rice and maize—account for more than half of the global dietary energy supply. Consequently, hundreds of edible plant species are neglected or underutilized, despite their nutritional value.

The main reasons why traditional food crops are being neglected in the HKH region are deterioration of local food systems, changing food habits, the perception of NUFCs as inferior food items, lack of knowledge about the cultivation of NUFCs and lack of awareness of the uses and nutritional value of NUFCs. These factors are not substantially different from other regions, but the rate of change in and impact of these factors are very high in the HKH region. For instance, local food systems are deteriorating faster in the HKH than other regions and resulting in loss of biodiversity and reduced dietary diversity. NUFCs are also largely overlooked by programs and policies for agriculture, food security and nutrition. As a result, the production of NUFCs has declined in the HKH. For instance, in the Khyber Pakhtunkhwa province of Pakistan, the average production of barley declined by 50% between the mid-1990s and 2010. Likewise, the production of sorghum and millet dropped by 62% and 67%, respectively, from the mid-1990s–2010. In Nepal, while the production of NUFCs has shown a moderate increase in absolute terms, per capita production of most NUFCs has either declined or shown negligible fluctuations. Consumption of NUFCs is also declining in the HKH. In the Balochistan and Khyber Pakhtunkhwa provinces of Pakistan, NUFCs, such as sorghum, barley and millets, collectively contribute only 0.23% and 1.63% to per-day per capita calorie intake, respectively. In Nepal, NUFCs, such as millets, barley, buckwheat, black gram and horse gram, contribute only 3.84% to annul per capita food intake.

In the countries of the HKH region, the prevalence of food and nutrition insecurity is quite high in the mountains. For instance, in Balochistan province of Pakistan, around two-thirds of the population are food insecure, and the prevalence of stunting, wasting and underweight in children (aged < 5 year) is 82%, 13% and 37%, respectively, which is significantly higher than national statistics. Similarly, in the mountains of Nepal, almost 60% of households are food insecure, and the prevalence of stunting and underweight in children (aged < 5 year) is 53% and 36%, respectively, which is significantly higher than national figures (which are 41% and 29%, respectively). Although there are several reasons for this high nutrition insecurity in the mountains, the most prominent reason is the neglect and underutilization of traditional food crops.

Incorporating NUFCs into the local food system will strengthen both determinants of nutrition security in the mountains, namely: food security and health. Enhanced production of these crops will result in enhanced local food supply and diversity in available food items. Mountain people's physical access to food will improve due to the local production of diverse food items. Enhanced production will also improve the income of farmers, which, in turn, will help them to access other food items. In addition, establishing food value chains and a processing industry will improve the income opportunities for local people, thereby increasing their income. Improved consumption of NUFCs will reduce the chances of micronutrient deficiencies in mountain people, leading to less health issues. As NUFCs are less dependent on chemical fertilizers and pesticides, the chances of chemical-induced health hazards will also decrease. Most importantly, integrating NUFCs into local food systems will reduce the climatic and economic risks associated with advanced cereals and cash crops.

NUFCs are also a good way of bringing balance to local food systems. They have the potential not only to improve farmers' incomes, but also the overall food and nutrition security in mountain regions by offering diverse food production at affordable prices with less risks. The contribution of NUFCs to improving food security and health is due to the improvement in dietary diversity and intake of micronutrients, which reduces the prevalence of stunting, wasting and underweight

in children (aged < 5 years). This also reduces the prevalence of underweight and micronutrient deficiency in women.

NUFCs have high nutritional value, but their role in the nutrition security of mountain people is not adequately understood; and they have not been mainstreamed in the policies and programs for agriculture, food security and nutrition. In view of their nutritional value, there is an urgent need to mainstream NFUCs into government programs and policies in order to integrate them into local food systems in the mountains. This will not only improve the nutrition security of mountain areas, but will also have positive impacts on biodiversity and local mountain economies. Accordingly, this study suggests a strategic framework for integrating NUFCs into the local food systems, which consists of the follows steps:

- Mainstream NFUCs into policies and programs
- Document indigenous knowledge on NFUCs
- Ensure the availability of germplasm for NFUCs
- Provide incentives to farmers to cultivate NFUCs
- Create institutional mechanisms (market facilities, extension services, credit and ICTs)
- Raise awareness about the nutritional value of NFUCs
- Support local food chains and establish a local processing industry
- Link NFUCs with tourism and school feeding programs

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