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Are Traditional Food Crops Really 'Future Smart Foods?' A Sustainability Perspective

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Abstract: This study attempted to assess the potential of traditional food crops (TFCs) to be 'future smart foods' through the lens of sustainability. Our study mainly relied on the primary data collected from farm households (n = 89) in the high mountains of Nepal and the hills of Bangladesh. The study found that farmers are gradually abandoning the cultivation of TFCs. In the last decade, cash crops such as mustard and cardamom in study villages in Nepal (SVN) and fruits and coffee in study villages in Bangladesh (SVB) were adopted to replace TFCs. In overall calorie intake at the household level, TFCs contributed only 3% and 7% respectively, in SVN and SVB. A sustainability analysis showed that TFCs have a huge potential to be 'future smart foods' because they are socially acceptable, have high nutritional values (social sustainability), and are key to the agrobiodiversity and resilience of farming systems (environmental sustainability). They also have the potential to improve famers' income and are more efficient in energy use during production cycles (economic sustainability). To promote TFCs as a sustainable solution for local farming systems and nutrition security, there is the need for a behavior change of both farmers and consumers, respectively, through the favorable policy environment and public awareness.

Keywords: Traditional food crops; future smart foods; sustainability; Nepal; Bangladesh

1. Introduction

The people in the Hindu Kush Himalaya (HKH) are facing the serious challenge of malnutrition. About 50% of the population of this region suffers from malnutrition, and between one-fifth and one-half of children (<5 years of age), depending on the country, suffer from stunting, with a high incidence of wasting and underweight. Achieving the sustainable development goal of ending hunger and achieving food and nutrition security by 2030 seems difficult. The region's population is increasing quite quickly at close to 1.4% annually, and traditional agricultural systems are coming under pressure and failing to provide adequate food and income [1]. Among several factors affecting the food and nutrition security in the HKH, climate change and the loss of agrobiodiversity are the two most taunting factors. The rising impacts of climate change have further added to the problem due to changes in temperature and precipitation patterns, frequent floods, prolonged droughts, and fluctuation in the timing of seasons [2]. The loss of agrobiodiversity is another huge challenge affecting the dietary diversity and overall nutrition security of the mountain people [3,4].

The conservation of local crops, livestock landraces and traditional practices promotes agrobiodiversity while simultaneously strengthening farmers' capacity to cope with different types of adversity [5]. For example, in South Asian countries, particularly India, Nepal and Bangladesh, farmers are promoting traditional seed exchange practices like drought resistant seeds and abiotic stress tolerant crops for marginal areas [5]. In this regard, the role of local communities is key in maintaining and managing local genetic materials for food and nutrition security [6,7]. In other words, traditional agricultural systems are the repository of many crops and cultivators [4]. In the past, the household food baskets in the HKH consisted of many different edible plant species [3], indicating the richness of agrobiodiversity in the region. The Barahnaja system has been one of the most important traditional farming practices observed in the HKH in the past. It is a centuries-old practice [4,8,9] where traditional food crops (TFCs) such finger millet, amaranths, common kidney beans, buckwheat, black gram, green gram, mix of pulses, horse gram, soybean, and other crops are grown together in a mixed cropping pattern. This system helps maintain agrobiodiversity, maintains soil fertility, and meets the diverse food requirements of the local people [4].

In the recent past, changes in local food systems and food habits in the HKH have led to the deterioration of such traditional mountain food systems, resulting in a decline in agrobiodiversity and further increasing the risk of food and nutrition security [2,3]. TFCs are gradually disappearing from food systems, and current day policies in the HKH countries do not emphasize TFCs for research and technological advancements [3,10].

The stability of food production is critically important for sustaining food security, and genetic diversity in agriculture is fundamental to agro-ecosystem resilience and stability in food production [11,12]. A number of studies have reported that agrobiodiversity has contributed to improving the resilience of agriculture by reducing the risk of pests and disease [13–15]. In the HKH, the diversity in agro-resources has traditionally served as a natural insurance against disease and climatic fluctuations, as well as a mechanism to reduce vulnerability and improve stability in food production [16].

In the HKH, the high mountains in Nepal and the hilly areas in Bangladesh are known as the spots with the most diverse agricultural systems that allow for the local peoples' high dependence on TFCs for livelihoods and food security. Traditionally, in these areas, agro-biodiversity has been considered a backbone for the sustainable development of agriculture, food security and poverty alleviation [7,17]. Traditional farming is predominant in the mountain areas of Nepal, and 80% of the Nepalese population still follows traditional cultivation practices which integrate crops, livestock, fisheries, agroforestry, and other associated biological resources [5,18]. In Bangladesh, the geographical area is divided into thirty agro-ecological zones and has rich genetic diversity in crops, livestock, fish, trees and wildlife [19]. Subsistence agriculture is the main basis of livelihood in Bangladesh [17]. Shifting cultivation (locally known as Jhum) is the indigenous and major farming system practiced in the hilly areas of Bangladesh (Chittagong Hill Tracts), where farmers use their own indigenous or traditional knowledge to maintain a rich genetic pool of useful plant species [19–21]. Farmers in the Chittagong Hill Tracts use around 50 wild plant species as food to ensure food and nutrition security [21].

It seemed interesting to re-examine whether the local farming systems featuring TFCs are still operating and maintaining their importance for local livelihoods and food security. By conducting case studies in the high mountain areas of Nepal and in the hills of Bangladesh, this study attempted to analyze the importance of TFCs for sustainability in socio-ecosystems. Moreover, in the selected districts (Taplejung in Nepal and Bandarban Hill District in Bangladesh), studies on TFCs are very rare. It is also important to mention that, in 2017, the 'Food and Agriculture Organization's Regional Initiative on Zero Hunger Challenge' for Asia and the Pacific in consultation with national and international partners relabeled TFCs as 'future smart foods' in view of their emerging importance for climate change resilience, agrobiodiversity, agriculture sustainability, and food and nutrition security [22]. All these expected contributions of TFCs needed to be systematically analyzed using the field level data. This study also serves as robust evidence to validate the expected contributions.

2. Methodology

This study adopted the broader framework of sustainability with three dimensions (social, environmental and economic) to conduct an analysis of TFCs to study their role in the socio-ecosystems in the study areas. The study considered the aspects of nutritional value and social accessibility under the dimension of social sustainability, agrobiodiversity and resilience under environmental sustainability, as well as market value and energy use efficiency under the dimension of economic sustainability.

For the study, TFCs were defined as those crops which have historically remained an integral part of farming systems and dietary patterns in the HKH but, in the last couple of decades, have been neglected and underutilized. In past, TFCs have been termed differently by different research centers, international development organizations, and the government departments. Some common terms being used for these crops have been 'neglected and underutilized species' (NUS) [3] and orphan crops' [23]. In the recent past, in view of their importance for climate resilience, agrobiodiversity and nutrition security, these crops have been relabeled as 'future smart foods' [1] and/or 'super foods' [24].

In the HKH, the main traditional food crops (TFCs) include buckwheat (*Fagopyrum* spp.), millets (*Eleusine* Spp.), Amaranth (*Amaranthus* spp.), sorghum (*Sorghum bicolor*), barley (*Hordeum vulgare)*, sea-buckthorn (*Hippophae* spp.), naked barley (*Hordeum himalayens*), legumes (*Vigna* spp.), yam (*Dioscorea* spp.), sesame (*Sesamum indicum*), niger (*Guizotia abyssinica*), kaphal (*Myrica esculenta*), chiuri (*Diploknema butyracea*), amala (*Phyllanthus emblica*), pomelo (*Citrus maxima*), and jamun (*Syzygium cumini*) [25]. In this study, popular crops are considered as maize, wheat, rice, and cash crops (cardamom, vegetables, fruits, rubber etc.).

2.1. Study Sites

For this study, a 'case study' approach was adopted which was based on both quantitative and qualitative data. Villages (as study cases/sites) were selected from mountainous and hilly areas (falling under the HKH) of two countries, i.e., Nepal and Bangladesh. In Nepal, the Doku and Thebe villages located in the Phungling municipality (Figure 1) in Taplejung District were purposively selected based on the diversity in farming systems and local dependence on TFCs. Taplejung District lies in province number one in the north eastern mountainous region of Nepal. It is located between 27 °08′ N and 87° 33′ E and ranges from 670 meters to 8586 meters above sea level (asl). The area of the Phungling municipality is 125.57 km^2, and the total population is 26,406 [26]. Agriculture is still practiced as a major occupation by the people in the district. About 27,551 hectares of land are available for agriculture production in Taplejung. However, only 10,955 hectares re irrigated land, of which 5255 re irrigated all year round [27].

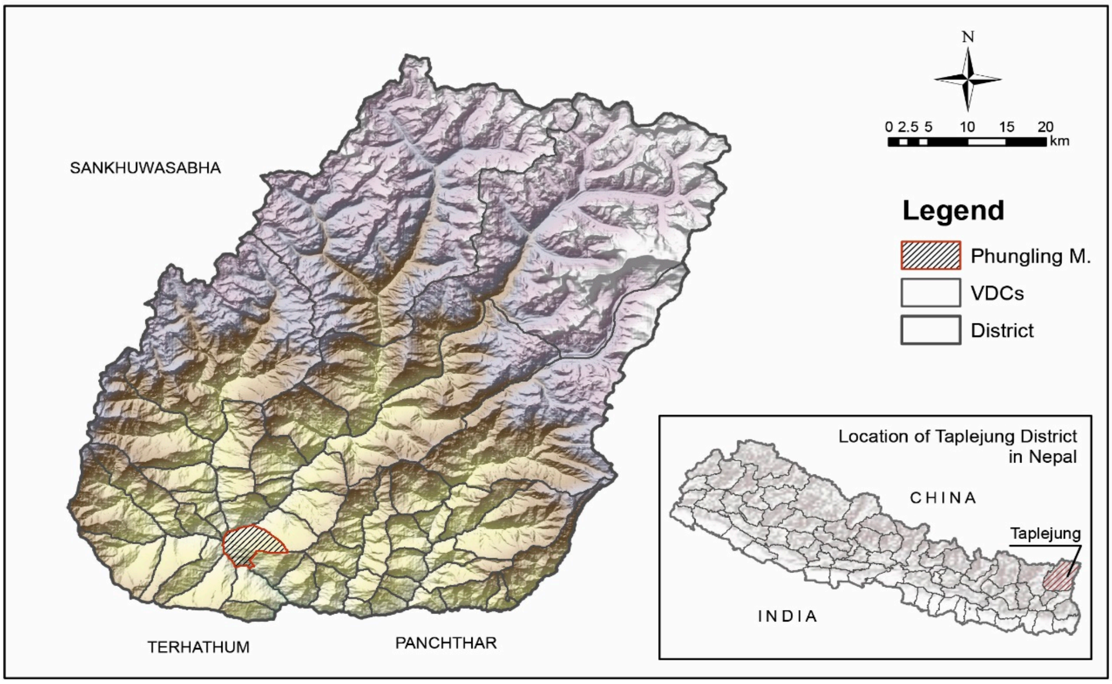

Figure 1. Site in Nepal.

In Bangladesh, the Mun Lai Para village, located in Ruma Sadar Union (sub-district) of Bandarban Hill District (BHD) in the Chittagong Hills Tracts (CHT), was purposively selected (Figure 2) based on the diversity in the farming systems featuring TFCs. Bandarban was identified as one of the three poorest districts in the CHT by the Planning Commission of Bangladesh [21]; the Ruma sub-district is among the most deprived areas in the country [21]. It is located between 21°53′ and 22°10′ N and 92°17′ and 92°34′ E at an altitude of 532 meters asl. According to the district statistics of 2011, Ruma is spread over 492.09 sq.km with a total population of 29,000. Agriculture, particularly Jhum farming (shifting cultivation), is one of the prime livelihood sources in Ruma. Around 15.5% of the total area in Bandarban is used for Jhum farming [21]. Among four major ethnic groups, the Ruma sub-district is mostly inhabited by the Bawn and Marma communities [28].

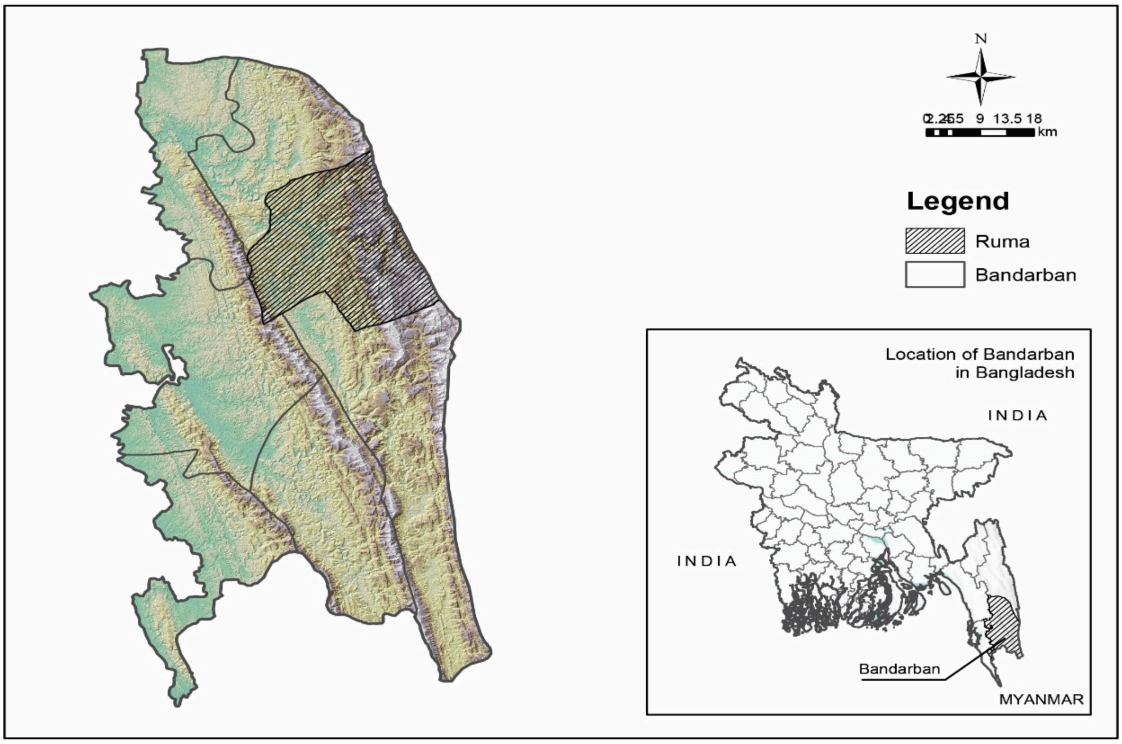

Figure 2. Site in Bangladesh.

2.2. Data Collection

Both primary and secondary data were collected from Taplejung District and the Ruma sub-district. For primary data, 89 farmers, in total, were interviewed in July–August 2017, comprising 59 from two study villages in Nepal (SVN) and 30 from one study village in Bangladesh (SVB). Farmers were randomly selected in study villages. Focus group discussions (FGDs) were also conducted to collect qualitative information from farmers. Qualitative information was also collected from the representatives of the government institutions through formal interviews. In Nepal, key institutes included the Nepal Agricultural Research Council (NARC) and District Agriculture Development Offices (DADO) (now renamed as Krishi Gyan Kendra). The NARC is responsible for conducting qualitative studies and research on different aspects of agriculture in Nepal. In Bangladesh, the Bangladesh Agriculture Research Institute (BARI) was selected as a key institution. The BARI is a key institute for deriving information on the status of TFCs in Bangladesh. It is the largest multi-crop research institute in the country that conducts research on wide variety of crops including cereals, tubers, pulses and vegetables. The information from the scientists, agriculture officers and other institutional representatives was used to cross check the information provided by the farmers. Such information was also used to support the discussion part of this paper.

Secondary data were collected through literature surveys from different journal articles, reports (published and unpublished), and official documents.

2.3. Data Analysis

The quantitative data analysis was mainly dependent on descriptive statistics, i.e., percentages and ratios. In the analysis, the energy use efficiency ratio for crops was estimated using Equation (1).

$$\text{Energy use efficiency} = \frac{\text{Energy output (MJ per unit land)}}{\text{Energy input (MJ per unit land)}} \quad (1)$$

In the Equation (1), the energy unit mega-joule is abbreviated as MJ.

Energy input and output were separately estimated. Energy input (per unit land) was estimated using the conversion criteria for each input in Table 1 and added to drive the overall figure. It is important to mention that machinery use was not converted into energy input because only a couple of farmers reported a very limited use of machinery. Energy output was estimated by converting the crop production (per unit land) into an energy equivalent using the conversion criteria presented in Table 1. Only the edible part of the production was converted to an energy equivalent. Non-edible parts of crop production such as leaves, straw, husk and other residues were not taken into account in the estimations of energy equivalents.

Table 1. Energy equivalent of inputs and outputs in crop production.

Inputs and Outputs		Unit	Energy Equivalent (MJ Per Unit)	
Inputs				
Human labor		Hour	Man: 1.96, woman: 1.57	
Machinery	Tractor	kg (deprecated mass)	93.61	
	Self-propelled		87.63	
	Other machinery		62.70	
Diesel fuel		Liter	56.31	
Chemicals	Herbicides	kg	238	
	Insecticides		101.2	
	Fungicides		216	
Chemical fertilizers	Nitrogen	kg	66.14	
	Phosphate (P_2O_5)		12.44	
	Potassium (K_2O)		11.15	
	Sulphur (S)		1.12	
	Zinc (Zn)		8.40	
Farmyard manure		kg	0.30	
Water for irrigation		m^3	1.02	
Electricity		kWh	3.6	
Seed		kg	Factor was used according to crop type	
Animal power	Ox	Day	10	(8 working hours per day)
	Buffalo	Day	9.5	(8 working hours per day)
	Horse	Day	18	(8 working hours per day)
	Donkey	Day	3	(4 working hours per day)

Table 1. *Cont.*

Inputs and Outputs	Unit	Energy Equivalent (MJ Per Unit)
Outputs		
Rice	kg	14.80
Maize		13.98
Ginger		2.30
Mustard		21.32
Buckwheat		14.35
Millets		14.56
Niger		21.36*
Soybean		15.88**

* Average value of black and grey Niger. ** Average value of brown and white soybean. Source: [29–32].

To estimate the dietary energy intake, the consumed quantities of food items (in the last 24 h) were converted to calorie intake per day per capita using the food composition tables of National Institute of Nutrition, India [32]. It is important to mention that some processed food items such as noodles and biscuits were not taken into account for conversions to dietary energy because of identified reporting errors in the quantities of these items. Therefore, it is cautioned that estimated calorie intake (per day per capita) is underestimated.

For food variety score (FVS) estimation, the reported number of food items consumed in last 24 h were counted. The FVS took into account the processed food items, but it counted each processed item (i.e., biscuit) as one item independent of its ingredients, because households could not report on the ingredients of such items.

3. Results

3.1. Households' Socioeconomic Characteristics

In the study villages in Nepal (SVN), the average household population size was 5.6, and more than 80% of farm households were headed by male members. However, in study villages in Bangladesh (SVB), the average household population size was 6.1, and almost all farm households were headed by male members (Table 2). The education status of the household head in the study villages in both countries was very low. In SVN, for two-thirds of the households, agriculture still remains a main source of their income. In SVB, for nearly 90% of households, agriculture remains a main income source. In both SVN and SVB, more than two household members were reported as engaged in agricultural practices. It is interesting to note that surveyed households in the study villages in both countries have decades of experience in agriculture. This implies that they have been engaged in agriculture for generations. The agricultural land holding size was smaller in SVN compared to that of SVB. In SVN, 22%–33% of farm households were reported to have access to institutional services such as formal credit and extension services. However, in SVB, no household reported such access.

Table 2. Characteristics of households.

Characteristics		Nepal (N = 59)	Bangladesh (N = 30)
Household size Mean (Std. Dev.)		5.6 (1.78)	6.1 (1.65)
Household head's sex	Male	83%	97%
	Female	17%	3%
Households who still rely on agriculture as their primary source of income		66%	87%
Education status of household head	Illiterate	22%	7%
	Primary schooling	63%	80%
	Intermediate and above	15%	13%

Table 2. *Cont.*

Characteristics	Nepal (N = 59)	Bangladesh (N = 30)
Number of migrants in the household Mean (Std. Dev.)	0.36 (0.120)	0.50 (0.82)
Household's experience in agriculture (years) Mean (Std. Dev.)	61.50 (35.24)	33.00 (17.47)
Number of household members involved in agriculture Mean (Std. Dev.)	2.62 (1.36)	2.37 (0.89)
Owned agricultural land* Mean (Std. Dev.)	10.97 (10.31) Ropani = 0.56 ha	4.6 (2.4) acre = 1.86 ha
Cultivated land* Mean (Std. Dev.)	6.20 (4.84) Ropani = 0.32 ha	4.1 (1.80) acre = 1.66 ha
Households having access to formal credit	33%	0%
Households having access to extension services	22%	0%

* Note: 1 Ropani = 0.05087 ha, and 1 acre = 0.4047 ha.

3.2. Decline of TFCs: Loss of Agrobiodiversity

In both SVN and SVB, farmers reported that they cultivated multiple crops in last 12 months. In SVN, all farmers reported that they cultivated maize, and almost 90% of farmers reported the cultivation of millets in last 12 months (Table 3). Around 15% of farmers reported the cultivation of mustard and rice, and only 6% cultivated buckwheat in last 12 months. A very small percentage of farmers reported the cultivation of niger, soybean and ginger in last 12 months. In SVB, over 90% of farmers reported the cultivation of rice and maize. Only 10% of farmers cultivated barley, and around 3% cultivated sesame.

Table 3. Traditional food crops (TFCs) and food security.

Indicator	Study Villages in Nepal (SVN)	Study Village in Bangladesh (SVB)
Average number of crops grown in the last 12 month; Mean (Std. Dev.)	2.30 (0.99)	2.03 (0.49)
Crops grown in the last 12 months* (% of households)	Maize (100); Millets (87.1); Mustard (14.9); Rice (14.9); Buckwheat (5.6); Niger (3.7); Soybean (3.7); Ginger (1.9)	Rice (96.7); Maize (93.4); Barley (10); Sesame (3.4)
Crops abandoned by households (% HH) in the last 10 years	Buckwheat (30.6); Barley 15.3); Millets (5.1): Rice (3.4)	Sorghum (66.7); Millets (43.4); Barley (40); Maize (3.4); Sesame (3.4)
Crops adopted to replace abandoned crops (% of households) in the last 10 years	Mustard (6.8); Cardamom (5.1); Maize (3.4); Wheat (3.4); Spinach (1.7)	Mango (36.7); Coffee (30); Orange (13.4); Litchi (10); Banana (6.7); Coconut (6.7); Papaya (3.4); Pineapple (3.4); Jack fruit (3.4); Rubber (3.4)
Number of TFCs abandoned in the last 10 years; Mean (Std. Dev.)	1.55(0.67)	2.37 (1.01)
Food variety score**; Mean (Std. Dev.)	9.1 (4.97)	9.9 (1.95)
Dietary energy intake per person per day*** (Kcal per day per capita)	1106 (840.4)	1379 (997.5)
Share of TFCs in calorie intake	7%	3%

Note: TFCs: Millets, buckwheat, barley, niger, sorghum, soybean, and jack fruit; the last 10 years refer to the period '2007–2017.' * For SVB, crops cultivated in last 12 months did not include perennial crops such as fruits and rubber; ** The number of food items consumed by household in last 24 h; *** Dietary energy also took into account the purchased food items.

Farmers reported vast experience in agriculture (Table 1), and during FGDs, they revealed that they had been cultivating TFCs on their farms since the start of farming by their households. These crops were embedded in their culture and social values. Survey results showed that in the last 10 years, farmers gradually abandoned the cultivation of TFCs. In SVN, a third of farmers reported that they abandoned the cultivation of buckwheat in the last 10 years. Likewise, around 15% and 5% of farmers reported the abandonment of barley and millets, respectively. On average, each farmer abandoned more than one crop (1.55) in the last 10 years. A majority of farmers expanded their area under cultivation of maize, and some farmers who were not cultivating it previously started the cultivation of maize. A notable percentage of farmers started cultivating mustard, cardamom, wheat, and spinach (Table 3). Overall, a decline of TFCs has led to a loss of agrobiodiversity in SVN.

In SVB, two thirds of farmers abandoned the cultivation of sorghum, and around 45% abandoned the cultivation of barley in the last 10 years. A small percentage of farmers stopped cultivating maize and sesame (Table 3). On average, each farmer abandoned more than two crops (2.37) in the last 10 years. Farmers adopted cash crops such as fruits, coffee and rubber in view of their market values. Almost 40% of farmers grew mango, and around 15% grew orange orchards. Around 7% of farmers started growing banana and coconut. A small proportion of farmers started growing papaya, pineapple, jack fruit and rubber in the last 10 years.

Representatives of DADO in Taplejung District and the NARC (in Nepal) also validated that the TFCs have been declining in the district, and farmers are mostly interested in cash crops. They reported that DADO did not promote TFCs aggressively because there was no demand from the farmers. Though TFCs, particularly millets, can be grown in climate change-induced water stress conditions, farmers are still more interested in tolerant varieties of popular cereals. During FGDs, farmers also reported that TFCs such as millets and buckwheat are more resilient to climatic stresses, i.e., extreme cold and water stress, but they choose to cultivate popular crops in view of their better market values.

Likewise, officials from the BARI in Bangladesh reported that the main focus of their research and development in the hilly areas remains on maize, rice and fruits. At present, there is no institutional mechanism for promotion- and market-based solutions for TFCs in the hilly areas of Bangladesh.

3.3. Household Food Security

A food security assessment in both SVN and SVB showed that farmers' households gradually lost variety in their food baskets. In SVN and SVB, the food variety scores were, respectively, 9.1 and 9.9, which are very low compared to plain areas in the HKH countries. A study [33] conducted in the plain areas of Pakistan found that households had a food variety score of 26 in the summer and a score of 35 in the winter. In study villages, the calorie intake by the households was also very low compared to the respective national standards in Nepal and Bangladesh. In SVN, calorie intake was 1106 kcal/day/capita, and in SVB, it was around 1379 kcal/day/capita. The minimum average adequate dietary energy requirement for Nepal and Bangladesh are, respectively, 2220 [34] and 1780 kcal/day/capita [35]. More importantly, the share of TFCs in the total calorie intake in SVN and SVB was only 7% and 4%, respectively.

3.4. Energy Use Efficiency: Traditional vs. Popular Crops

The estimates of the energy use efficiency ratio (EER) revealed that TFCs have advantages compared to the popular crops in SVN. The EER value for rice was 5.51, and for the traditional crop buckwheat, the value was 6.04 (Table 4). Likewise, the EER value for millets (1.78) was significantly higher than that of maize (1.05). The EER value for niger was also better than that of maize. However, soybean had the highest EER value (7.97) among all crops. It is interesting that some cash crops such as mustard and ginger had a low EER value, revealing that these crops may be profitable in terms of monetary value but are not efficient in energy use.

In SVB, rice was the most efficient in energy use (EER 3.2) (Table 5), but it was less efficient compared to rice in SVN (Table 5). However, barley was almost equal to maize in terms of energy use efficiency. This implies that maize and barley can be considered as substitutes to each other while making decisions on crops.

Table 4. Energy use efficiency ratio in study villages in Nepal.

Crops		*Energy Input (MJ per Ropani)	*Energy Output (MJ per Ropani)	Energy Use Efficiency Ratio
Popular crops	Rice	524	2888	5.51
	Maize	1351	1413	1.05
	Ginger	383	262	0.68
	Mustard	133	61	0.46
TFCs	Buckwheat	46	278	6.04
	Millets	201	357	1.78
	Niger	908	1797	1.98
	Soybean	32	255	7.97

* Computed among those farm households who cultivated the respective crop.

Table 5. Energy use efficiency ratio in study village in Bangladesh.

Crops		*Energy Input (MJ per Acre)	*Energy Output (MJ per Acre)	Energy Use Efficiency Ratio
Popular crops	Maize	6104	11769	1.9
	Rice	2866	9169	3.2
	Sesame	1437	1047	0.7
TFCs	Barley	2756	4924	1.8

* Computed among those farm households who cultivated the respective crop.

3.5. Market Value of TFCs

During FGDs, farmers revealed that the market values of TFCs is very low compared to popular crops, particularly cash crops. In SVN, farmers quoted an example that they can produce only 20–40 kg of millets per ropani of land that can generate revenue of only NPR 2000–4000 (≈ USD 17–35). On the other hand, they can use same piece of land to produce 8 kg of cardamom with a value of NPR 80,000 (≈ USD 700). In SVB, farmers also reported that TFCs have a low market value, and they prefer to grow fruits with higher market values. In study villages in both countries, farmers mainly compared TFCs with cash crops during discussions, and they were more likely to replace TFCs with cash crops (consistent with Table 3). It is interesting to note that farmers did not compare popular cereals with cash crops despite comparable prices of TFCs and popular cereals. This implies that the abandonment of TFCs is not merely driven by market value. There are some other factors such as changing local dietary habits that are influencing farmers' decisions on crop choices.

4. Discussions

This section discusses the reasons for the decline of TFCs and their possible contribution to the sustainability in the socio-ecosystems.

4.1. Why Are TFCs Neglected and Underutilized?

The results showed that farmers in both SVN and SVB are gradually replacing the TFCs with popular cereals or cash crops. The production of TFCs gradually declined in almost all areas of the HKH, not only in the study villages. For instance, in Khyber Pakhtunkhwa (KPK), Pakistan, the average production of barley was more than 60 thousand metric tons during the mid-1990s. It has gradually declined to only 30 thousand metric tons in the second half of the 2010s [1]. In Nepal, the production of TFCs between 2007 and 2014, in absolute terms, has shown a moderate increase [36]. However, in terms of per capita production, these crops have either shown a decline or negligible change in production over time [37]. In this study, discussions with the local people and the representatives of government departments revealed that the major factor of this shift from TFC varieties to the new ones has been driven by declining market values and a demand for TFC. People have now started considering NUS as "foods of the poor" [3,38] and are not aware of their potential for production, income, and nutrition security.

Food habits and diets in the HKH have been undergoing changes in recent years due to socioeconomic developments linked to increased access to roads, schools, and markets, as well as increased access to radio, television, and other media [39,40]. Changes have been more prominent in middle and lower altitude villages, where road connections are better and market connections have been established.

Among other factors, inadequate policy support has resulted in the low production of TFCs and has triggered a preference for rice, wheat, maize, and cash crops (such as, potato and other vegetables) in mountain agriculture systems [3].

4.2. Social Sustainability: Nutritional Value and Social Acceptability

TFCs are relatively richer in micronutrients (Table 6). However, our field discussions showed that the local people are not properly aware of the nutritional values of TFCs. This is the reason why TFCs contributes only a very tiny share (3%–7%) to overall calorie intake by the households (Table 3). Historically, TFCs have been socially and culturally acceptable for local communities in the HKH because these crops have remained an integral part of the dietary patterns of the people. Moreover, in most parts of the mountain areas, the poor people have had a very limited choice of food items due to their low income levels and physical isolation. They have had a high dependency on TFCs for their food and nutrition security because these crops are comparatively less expensive, rich in micronutrients, and good alternatives to expensive food items [3,38].

However, in the recent past, the preference for TFCs has declined, and the younger generation prefers popular cereals and instant food items. This has had many implications in terms of changes in farming systems, including the replacement of TFCs with popular food crops (Table 3). Some studies [1,3] have reported that the awareness about the importance of TFCs for food and nutrition security is improving in both rural mountain areas and urban centers. For example, in the Gatlang area of the Rasuwa district in Nepal, farmers are still cultivating TFCs, and their production and diets are diverse [3], which is conducive to improving local food and nutrition security [3]. Diversity in production and diets is the key to better food and nutrition security, as reported elsewhere [41–44]. In study villages, during FGDs with farmers, it was found that despite the decline in the preference for TFCs in the recent past, farmers were still willing to revitalize these crops in their farming systems. They want proper institutional support and better market values for these crops. This implies that TFCs are still socially acceptable and can be revitalized in farming with proper support mechanisms. Rasul et al. [1] suggested that in addition to improving the production of TFCs, special efforts are required to change the dietary habits in the mountain areas to revitalize TFCs.

Table 6. Nutritional values of some examples of traditional food crops (TFCs).

Crops	Botanical Name	Nutritive Value Per 100 Gram							
		kcal	**Protein (g)**	**Dietary Fiber (g)**	**Thiamine (mg)**	**Riboflavin (mg)**	**Calcium (mg)**	**Iron (mg)**	**Zinc (mg)**
Amaranthus (seed, black)	*Amaranthus cruentus*	356	14.6	7.0	0.0	0.0	181.0	9.3	2.66
Pearl millet	*Pennisetum typhoideum*	348	11.0	11.5	0.3	0.2	27.4	6.4	2.76
Barley	*Hordeum vulgare*	316	10.9	15.6	0.4	0.2	28.6	1.6	1.5
Sorghum	*Sorghum vulgare*	334	10.0	10.2	0.4	0.1	27.6	4.0	1.96
Quinoa	*Chenopodium quinoa*	328	13.1	14.7	0.8	0.2	198.0	7.5	3.31
Little millet	*Panicum miliare*	346	10.1	7.7	0.3	0.1	16.1	1.3	1.82
Foxtail millet	*Setaria italica*	332	8.9	6.4	0.3	0.2	15.3	2.3	1.65
Finger millet	*Eleusine coracana*	321	7.2	11.2	0.4	0.2	364.0	4.6	2.53
Maize (dry)	*Zea mays*	334	8.8	12.24	0.33	0.09	8.91	2.49	2.27
Wheat (whole)	*Triticum aestivum*	322	10.59	11.23	0.46	0.15	39.36	3.97	2.85
Rice (raw, milled)	*Oryza sativa*	356	7.94	2.81	0.05	0.05	7.49	0.65	1.21

Source: [32].

4.3. Environmental Sustainability: Agrobiodiversity and Resilience of Farming Systems

In the study villages, farmers abandoned the cultivation of important TFCs (on average, they abandoned two crops in 10 years) (Table 3). This gradual decline of TFCs from the farming systems has resulted in a loss of agrobiodiversity and has serious implications for the environment and essential ecosystem services such as pollination, water retention, nutrient cycling, and decomposition, as reported elsewhere [45]. The decline in natural pollinators may adversely affect crop productivity, as found by Pratap and Pratap [46] in the case of apple production in Himachal Pradesh, India. Similarly, the move towards cash crops has resulted in an increased demand for irrigation water [46]. This has ultimately led to the overexploitation of water resources in the mountain ecosystems [1]. These aspects are adversely affecting the resilience of farming systems in the long run. The disappearance of TFCs has also had some immediate impacts on food systems. For instance, discussions with local people and with the government officials revealed that TFCs are more resilient to climate-induced stresses. This implies that agriculture is gradually getting more vulnerable to climatic stresses with the loss of TFCs [1,3].

Diversity in agro-resources traditionally served as a natural insurance against disease and climatic fluctuations, as well as a mechanism to reduce vulnerability and improve stability in food production [16,47]. If properly harnessed, TFCs can improve the agrobiodiversity, food and nutrition security, and overall resilience of farming systems in the HKH [3,47]. A study in the Indrawati basin in Nepal found that farmers used crop diversification as a mechanism to minimize the climate change-induced risk of crop failure [48]. In the Kailash Sacred Landscape in Nepal, farmers used TFCs and native livestock to reduce risks and improve stability in food production [49]. In addition to minimizing risks and improving stability, genetic diversity in agriculture also directly contributes to dietary diversity and nutritional status.

4.4. Economic Sustainability: Market Value and Energy Use Efficiency

The current situation in the field showed that TFCs have very low market values and demand, and farmers are replacing these crops with high value crops (Table 3). There is a prospect to increase the range of food products prepared from TFCs to make them more palatable for the locals and to improve their market demand [1,3]. Provided that proper value chains are developed for these crops, TFCs are good options in terms of bringing a balance to local food systems and improving farmers' income. In recent years, an increased dependency on external food crops and processed snacks and drinks have made mountain people more vulnerable to food and nutrition insecurity. Price shocks in food-producing areas and natural disasters (such as floods and landslides) may result in restricted food supplies and price hikes in the mountain areas. Promoting TFCs can help to improve the stability of local food supplies, reduce dependency on external food items, and improve the nutritional status of the local people. Merrey et al. [50] found that in the Rasuwa district of Nepal, farmers in the high altitude areas in this district (i.e., Gatlang and Grey) cultivate TFCs such as millets, local sweet maize, barley, and local beans, and they raise native livestock, such as yak and chauri (a cross breed of yak with cow). They sell their products to local resorts and hotels at very good prices, resulting in a better income. Almost all of the local resorts and hotels in Gatlang, Grey, and adjoining areas offer food prepared from these TFCs to tourists [3].

The most important point is that TFCs have better energy use efficiency compared to other crops in SVN (Table 4), and they have competitive status in SVB (Table 5). This implies that if TFCs are adopted by farmers, their investments in inputs are likely to reduce.

4.5. TFCs as 'Future Smart Foods': A Way Forward

TFCs have a huge potential to be future smart foods [22,51]. The above discussion reveals that these crops are more likely to contribute to the sustainability in socio-ecosystems through achieving sustainable food and nutrition security, the resilience of farming systems, and agrobiodiversity.

There is need for behavior changes for both producers (farmers) and consumers (local people and beyond) to prioritize these crops in the food systems. To change the behavior of farmers, adequate institutional and policy support is required to create TFC-enabling environments. Some examples of such support include creating awareness of farmers on the importance of TFCs for agrobiodiversity and climate resilience, linking credit schemes to TFCs, providing related extension services, improving storage and processing facilities, investing in research on these crops, establishing a 'support price' mechanism, linking these crops with other enterprises such as ecotourism (see [3]), and avoiding conflicting policy steps (i.e., subsidies on popular food items in areas where TFCs are grown). To change the behavior of consumers, adequate steps can be taken for improving public knowledge on the nutritional values of TFCs and their importance for dietary diversity for nutrition security, integrating these crops in school curricula and feeding programs, promoting their values as products, and diversifying the products to expand the range of options for consumers. There a few examples from Nepal that TFCs are being promoted to attract consumers. For example, products like oatmeal, buckwheat flour, and millet cakes can now be purchased in major supermarkets [1]. The demand for such products is steadily increasing with increasing consumer awareness [1].

5. Conclusions

In the Hindu Kush Himalaya (HKH) region, traditional food crops (TFCs) are gradually disappearing from local farming systems. This has serious implications for sustainability in the socio-ecosystems. Drawing on case studies from the mountainous and hilly regions of Nepal and Bangladesh, this study found that farmers have been replacing TFCs—i.e., buckwheat, millets and barley—with cash crops—i.e., mustard, cardamom, fruits and coffee. A food security assessment at household level showed that food variety in consumption and calorie intake are very low compared to national standards of respective countries. TFCs only contributed to 3%–7% of the overall calorie intake (per day per capita) in the study areas.

TFCs have a huge potential to be 'future smart foods' if they are revitalized in local farming systems. Findings showed that these crops are likely to improve sustainability in socio-ecosystems. They are socially acceptable, have high nutritional values (social sustainability), and are key to improving the agrobiodiversity and resilience of farming systems (environmental sustainability). Moreover, they are efficient in energy use, implying that they require less investment in inputs and have a high potential to be income generating sources (economic sustainability).

To promote TFCs as a sustainable solution to improve resilience, agrobiodiversity, nutrition security, and economic benefits in local food systems, there is need for behavior changes for both producers (farmers) and consumers (local people and beyond). To change the behavior of farmers, adequate institutional and policy support is required to create TFC-enabling environments. To change the behavior of consumers, there is need to improve the public awareness on the nutritional values of TFCs and their importance for dietary diversity and nutrition security. The promotion of their value chain development and introducing the diverse range of products can also result in the improved demand of the consumers.

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