sustainability

MDPI

Article

Climate Change, Mountain Food Systems, and Emerging Opportunities: A Study from the Hindu Kush Karakoram Pamir Landscape, Pakistan

Abid Hussain [1,*], Faisal Mueen Qamar [1], Lipy Adhikari [1], Asif Iqbal Hunzai [2], Atta ur Rehman [3] and Kosar Bano [1]

[1] International Centre for Integrated Mountain Development, Kathmandu 44600, Nepal; Faisal.Qamer@icimod.org (F.M.Q.); lipy.adhikari@icimod.org (L.A.); kosar.bano@icimod.org (K.B.)
[2] World Wide Fund for Nature, Gilgit 15100, Pakistan; hunzaiasif@gmail.com
[3] Agha Khan Rural Support Programme, Chitral 17200, Pakistan; attaurrehmanlal@gmail.com
* Correspondence: abid.hussain@icimod.org

Abstract: This study investigated the mountain food systems in the Hindu Kush Karakoram Pamir Landscape (HKPL) in Pakistan. It analyzed the impacts of climate change on agriculture and livestock and identified key opportunities which can be tapped into to improve sustainability in food systems. The study applied a "multiple case studies approach" and collected data from four study sites at different altitudes, using the method of slow focus group discussions, key informant interviews, and non-participant observation. Findings revealed that the contribution of local agriculture and livestock to people's food consumption has gradually declined, increasing their dependence on external food items. Local food systems are losing diversity, which has negatively impacted people's dietary diversity. The youth has lost interest in agriculture due to low productivity and profitability in a high altitude village—Misgar (≈3200 m above sea level). In all sites, local people perceived mixed impacts (both positive and negative) of climate change on food systems. Climate change together with enhanced use of pesticides and inorganic fertilizers, high yielding seed, and improved farm management have positive, and climate-attributed increase in crop pest attacks has negative impact on crop productivity. Moreover, local people perceived negative impacts of climate change on pastures and water availability in traditional irrigation systems without significant influence on crop and livestock productivity. In food systems, these are needed to maximize benefits from the local potential for organic production, livestock integration, value chain development, traditional food crops, medicinal plants, and protected vegetables cultivation to reduce the vulnerability of food systems to climactic and economic shocks, and improve the sustainability.

Keywords: mountains; food systems; agriculture; livestock; food security; climate change; opportunities; Hindu Kush Karakoram Pamir Landscape (HKPL)

Citation: Hussain, A.; Qamar, F.M.; Adhikari, L.; Hunzai, A.I.; Rehman, A.u.; Bano, K. Climate Change, Mountain Food Systems, and Emerging Opportunities: A Study from the Hindu Kush Karakoram Pamir Landscape, Pakistan. *Sustainability* **2021**, *13*, 3057. https://doi.org/10.3390/su13063057

Academic Editor: Tek Sapkota

Received: 25 November 2020
Accepted: 12 February 2021
Published: 11 March 2021

1. Introduction

Food insecurity remains a major challenge in the Hindu-Kush Himalayas (HKH) where around one-third population is facing food insecurity, and almost half suffers from malnutrition [1] (the HKH region extends 3500 km across eight countries—Afghanistan, Bangladesh, Bhutan, China, India, Nepal, Myanmar, and Pakistan—covering an area of 3,441,719 km^2, and accommodating around 240 million people). Achieving Sustainable Development Goal (SDG) 2 on zero hunger is very difficult without strengthening food systems in the mountains. In the HKH, nudged topography, inaccessibility, poor market connectivity, declining agrobiodiversity, and high outmigration are posing serious challenges to food production and agricultural income [2–5]. The rising impacts of climate change in the fragile mountain ecosystem coupled with local natural resource-dependent

economies have further worsened the situation of food and nutrition insecurity [1]. Resultantly, the dependence of the mountain areas on the plains for food supplies has increased over time. For example, in Pakistan, around 60% of food demand in mountain areas is met by the plain provinces [6,7].

In the HKH, the Hindu Kush Karakoram Pamir Landscape (HKPL) is one of the high altitude landscapes where food security is highly vulnerable to climatic and socioeconomic factors (the HKPL is shared by four countries—Afghanistan, China, Pakistan, and Tajikistan. Tajikistan in not a part of the HKH but its area in the HKPL is important to look at the landscape in a holistic manner). In the HKPL, agriculture and livestock (i.e., goat, sheep, and yak) are the most important sources of local food security and livelihoods. In agriculture, the role of women is gradually increasing due to the decreasing interest of youth and male members in this sector. Women's increasing workload and responsibilities do not correspond to their rights and rewards [7]. Overall, a significant proportion of the population in the HKPL areas faces food and nutrition insecurity. For instance, in the Badakhshan province of Afghanistan, more than half of the population is food insecure and face protein deficiencies. In this province, changing precipitation patterns have resulted in a substantial decrease in agricultural and livestock production, and income (by 33%) [8]. Likewise, in the Chitral district of Pakistan, almost half of the population is food insecure [9]. Water variability in the traditional micro-irrigation systems and climate change-induced extreme events (i.e., floods) are impacting agricultural productivity. In Tajikistan, "Gorno Badakhshan Autonomous Oblast" (GBAO) is one of the most food insecure areas of Tajikistan where around 23% children (aged 6–59 months) are facing stunting, and 43% are suffering from hemoglobin anemia [10]. GBAO is also facing several challenges induced by climate change and labor shortages due to high outmigration rate [10,11].

Overall, climate change is one of the leading causes of high prevalence of food insecurity in the HKPL. Changes in precipitation patterns and hydrological imbalances, changes in temperature, frequent floods, and droughts are not only affecting agriculture, but also triggering an increase in the degradation of forests and rangelands [1,7]. In mountain areas, the severity of climate change impacts may vary from one area to other even within same region. Climate change may also have both positive and negative impacts in the same area. For example, in Upper Chitral, snow covered high-altitude areas now receive less snowfall in winter (compared to the past) and have become suitable for the early cultivation of vegetables [12]. Simultaneously, this decline in snowfall on high altitudes, together with temperature rise, may also lead to low water availability in the valleys and consequent decline in crop production, as reported by preceding studies in mountain areas [13–15]. Due to high altitude, the ecosystems and their response to rising risks are more complex in the HKPL and call for in-depth research. Currently, dynamics of food systems and climate change-induced local impacts in the HKPL are the least researched areas. It is very important to adequately understand the localized impacts of climatic and other key factors, and identify key opportunities to reduce vulnerability and improve sustainability in food systems [16–18]. This study attempts to investigate such key areas in-depth, using the qualitative multiple case studies approach. The study has drawn cases (sites) only from the HKPL area of Pakistan. However, in future, cases from other two countries—Afghanistan and Tajikistan will also be researched. The study specifically investigates the local impacts of climate change, corresponding changes in food systems, and key potentials and opportunities emerging in change climate in selected study sites located at different altitudes (single, transitional, and double cropping zones). It is hoped that the study will generate robust evidence from the least researched areas, and help policy makers to better understand the local situation of agriculture and food security in high altitude mountain areas.

2. Methodology

2.1. Study Sites

The mountain areas in the HKPL part of Pakistan (Figures 1 and 2) are heterogeneous in terms of climatic conditions, elevation, and topography. Large parts of the Gilgit-Baltistan (GB) province and Chitral region of Khyber Pakhtunkhwa (KPK) province (two districts: Upper Chitral and Lower Chitral) are included in the HKPL. Agro-ecologically, GB and Chitral are classified as Northern Dry Mountain of Pakistan [16]. In terms of agricultural zonation, they are classified into four zones due to the difference in agro-ecological characteristics: double cropping zone (<1900 m above sea level (masl)), marginal double cropping or transitional cropping zone (1900–2300 masl), single cropping zone (2300–3000 masl), and alpine pastures with no cultivation (>3000 masl) but suitable for livestock grazing. The double cropping zone has potential for the cultivation of maize, wheat, and a vast range of vegetables and fruits. The transitional cropping zone is suitable for the cultivation of barley, wheat, and diverse fruits, nuts, and vegetables. The single cropping zone is suitable for the cultivation of potato, buckwheat, millets, barley, peas, beans, and fruits. Livestock rearing, either by landowners or transhumant pastoralists (herders who seasonally move livestock between summer and winter pastures), is common to all four subzones [18].

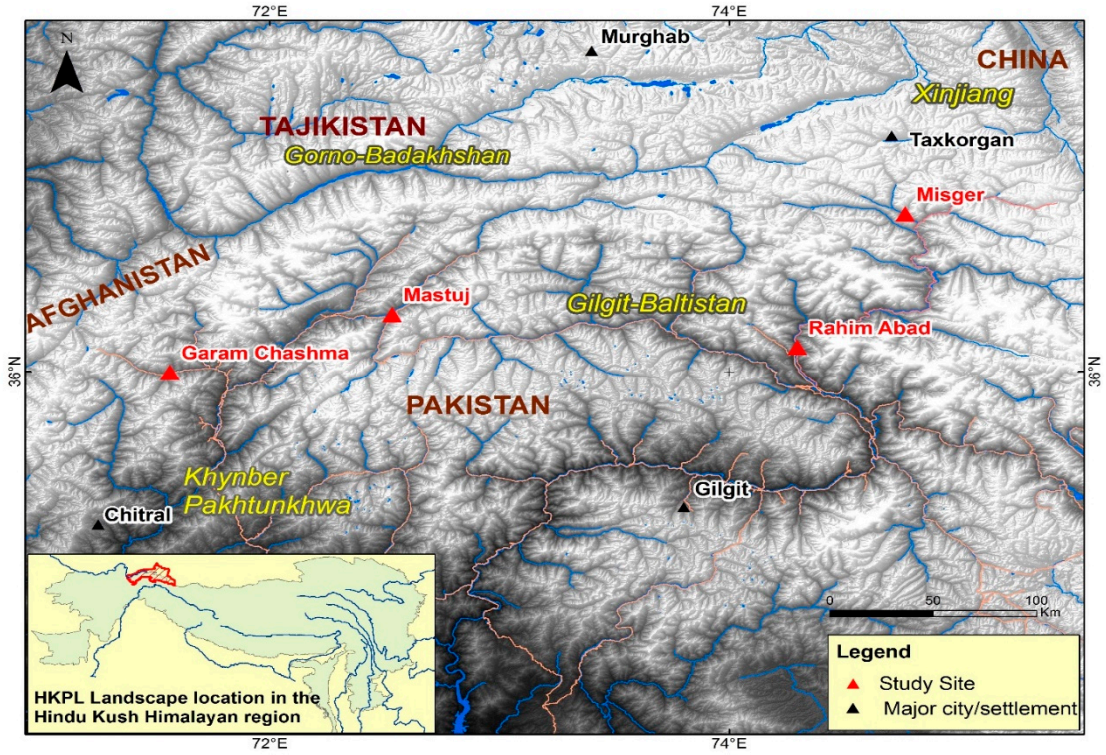

Figure 1. Study sites in the Hindu Kush Karakoram Pamir Landscape (HKPL).

For this study, four sites were selected for data collection (Table 1) keeping in view the factors of geographical location (GB and Chitral) and cropping zonation. Rahim Abad and Misgar are located in the GB province, and Garam Chashma and Mastuj are located in Chitral region (consisting of two districts – Upper Chitral and Lower Chitral) of the KPK province. In GB, Rahim Abad village (1625 masl) located 35 km in the north-west of Gilt city (capital of GB province) falls in a double cropping zone with good access to roads and market. Misgar village (3184 masl) falls in a single cropping zone and is situated in the northern end of Hunza District in GB, near Pakistan's border with China and Afghanistan. Garam Chashma (2250 masl) is one of the many branch valleys of Lower Chitral District. It is situated in the extreme north-west of Pakistan and falls in the transitional cropping

zone (also evident from Table 2). It is one of the highest human settlements in the Hindu Kush ranges. Mastuj (2300 masl) is a union council of Upper Chitral District. It falls in the transitional cropping zone with good access to market. Mastuj also operates as a higher administrative unit—*Tehsil*. However, in this study, data were collected only from one union council—Mastuj (same name as *Tehsil*).

Figure 2. Satellite image based geographical context of the study sites (Source: Google Earth).

Table 1. Study sites and data collection tools.

Indicators/Tools		Rahim Abad	Misgar	Garam Chashma	Mastuj
Altitude (above sea level)		1625 m	3184 m	2250 m	2300 m
Administrative status		Village	Village	Branch valley	Union council *
Cropping zone		Double	Single	Transitional	Transitional
Slow focus group discussions	Total participants	16	13	11	12
	Male participants	6	7	11	12
	Female participants	10	8	0	0
Interviews with key informants		• 1 interview in fruits/nuts processing factory • 1 interview with a village leader • 1 interview in Provincial Agriculture and Livestock Departments		• 1 interview with NGO representative • 1 interview in District Agriculture Department • Interview with local potato collector/contractor	• 1 interview with local experienced farmer
Field observations		We observed the cropping systems, water sources, and micro-irrigation systems.			

* A council of 6–8 villages.

Table 2. Crop calendar (five major crops).

Study Site	Crops	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.
Rahim Abad	Wheat												
	Maize												
	Potato												
	Beans												
	Peas												
Misgar	Potato												
	Wheat												
	Peas *												
	Barley *												
Garam Chashma	Potato												
	Wheat												
	Maize												
	Barley **												
	Peas ***												
Mastuj	Wheat												
	Barley												
	Maize												
	Potato												
	Tomato												

* In Misgar, two crops of peas are harvested. The first one is sown in April and harvested in June. The second one is sown in June and harvested in October. Barley is also cultivated twice. The first crop period is from April to June and the period for second crop is from June to September. ** Some farmers cultivate potato or maize after harvesting of barley. *** After harvesting peas, fodder crops are cultivated in Garam Chashma: 10 years ago, people used to grow barley after wheat but now they use this time for non-agricultural activities. Mastuj: growing two crops of wheat. Winter and spring wheats, spring wheat matures late.

As per reported information by the local people, in Rahim Abad, the weather in summer remains moderate and in winter the village receives occasional snowfall. In Misgar, weather in the winter remains extremely cold with heavy snowfall and temperature sometimes falls even below −20 °C. Summer weather remains moderate with maximum temperature touching 35 °C. In Garam Chashma and Mastuj, in winter temperature falls to −10 °C and in summer maximum temperature ranges from 20 °C to 25 °C (Table 3). Climatic data for the period of 2002–2019 derived from locally calibrated South Asian Land Data Assimilation Systems [19] showed that in Rahim Abad, the average temperature in the winter of 2019 remained below 0 °C and in summer it was 18 °C. In Misgar, average temperatures in winter and summer of 2019 were respectively −13 °C and around 10 °C. In both Garam Chashma and Mastuj, average temperatures of winter and summer remained around −10 °C and 14 °C, respectively, in 2019.

2.2. Research Design, Data Collection, and Analysis

This research is based on qualitative multiple case studies design (MCSD) and considers four study sites as "cases". The selection of cases is based on the geographical location (from two provinces) and crop zonation, but keeps the same subject of inquiry—high altitude agriculture and food security to compare the situation across cases, as revealed by various preceding studies [20–23]. MCSD is considered more reliable compared with the single case study design due to the possibility of more evidence from different sources or locations on a same subject of inquiry [24,25].

Table 3. Climatic characteristics and livelihoods.

Characteristics	Rahim Abad	Misgar	Garam Chashma	Mastuj
Local climate	Occasional snowfall in winter and moderate summer	Extremely cold winter (lowest temperature −20 °C Heavy snowfall in winter Summer is moderate (max. temperature 35 °C)	Extreme cold in winter (temperature falls to −10 °C) Summer is moderate (temperature remains around 25 °C in summer months)	Extreme cold in winter (temperature falls below −10 °C) Summer is moderate with max temperature slightly above 20 °C
Number of households	400	316 (only 150 are staying in village now, 166 out-migrated)	70–300	2200
Main income sources(Ranked by households in terms of importance. The most important is at top)	Agriculture Government jobs Private jobs Livestock Small businesses/shops Tourism Remittances	Remittances Livestock Government jobs Agriculture Tourisms	Agriculture Public and private jobs Small businesses Remittances	Agriculture Public and private jobs Livestock Small businesses Tourisms
Change in livelihood pattern during last 10 years	No clear shift from agriculture to non-agriculture income sources	A substantial shift from agriculture to non-agriculture income sources	No clear shift from agriculture to non-agriculture income sources	A slight shift from agriculture to non-agriculture income sources
% households with out-migrants *	5%	20% (of 150 households)	2–5% (in winter members from 50% households go to other areas for work **)	5% (of this, around 15% is inland migrants)

* A household member who stays outside of the home for six months or more is considered an out-migrant. ** Household male members mostly commute on daily basis to urban centres. However, a small proportion also out-migrate temporarily for 3–4 months. Source: Field notes.

In this study, data have been collected from local communities and key informants from local communities, enterprise (food processing factory), government departments, and local NGOs. To collect data from communities, a semi-structured checklist was prepared with more open-ended questions. To gather information from key informants, non-structured checklists containing key agenda points were used. However, discussions were not limited only to these key agenda points. Almost a month before the data collection, researchers identified local contact persons in the study sites who helped in identifying the focus groups from communities and key informants. They tried their best to ensure the participation of women in the focus groups (Table 1). However, in two sites, i.e., Garam Chashma and Mastuj, they faced difficulty in ensuring women' participation due to local cultural constraints. They also fixed time and date with community groups and all key informants. Finally, the data collection was carried out in October and November 2019.

For primary data collection, this study used a guiding tool—coordination schema (see Appendix A Table A1). This tool guided the data collection process through providing clear agenda points (broad aspects for discussions), sources of data/information, and tools for data collection. Overall, data were collected from community groups and different key informants. In addition, researchers also applied non-participant observation tool to examine the cropping patterns, water resources, and traditional irrigation systems. It helped in validating the information provided by the participants of the slow focus group discussions (SFGDs).

Data collection from local community groups was carried out using the method of slow focus group discussions. This method was based on the two key principles suggested

by Jentoft and Olsen [26]. First, researchers intentionally used handwritten notes, rather than voice recordings. It is visible evidence to respondents that they are being interviewed, as opposed to a casual conversation [26,27]. Respondents also get extra time to further reflect on the questions and organize their answers. This slowness enriches the data throughout the interview [26]. Second, the "equal voice approach" was used during discussions. After each question, respondents were given 2–3 min to discuss among themselves to reach a collective answer. During such discussions, researchers/enumerators observed very closely and encouraged less-vocal participants, particularly women, to give their opinion. Collective answers in SFGDs are more reliable than individual response in conventional focus group discussions (FGDs). There are less chances of misreporting in SFGDs because participants may remind each other about the past events. In conventional FDGs, particularly in perception-based studies (as this study is), there are high chances of misreporting due to recall errors of a few active respondents and suppression of voice of other participants.

It is important to mention that the study documented the local perception of climate change and its impacts through using the criteria of comparing the current situation (in 2019) with the situation of 10 years ago (2009 and earlier). Several similar studies [7,28] have used these criteria with a recall period of 10 years. Perceived changes in climatic factors are less reliable if the time period is less than 10 years because climate change is a long-term phenomenon. Likewise, the use of more than 10 years recall period for perception data is also likely to have recall bias due to reporting errors caused by long recall period, change of farmer's generation in agriculture, and outmigration of native farmers.

Key informant interviews were conducted using the conventional non-structured interview methods to further discuss the key areas identified during SFGDs. For example, during SFGDs, participants reported the role of the fruits/nuts processing factory (Rahim Abad), the exploitation of potato farmers by the middleman (Garam Chashma), the potential for yak and vegetables (Misgar), and the high potential of study areas for traditional food crops, native livestock, and organic farming (all study sites). To discuss these aspects in-depth, researchers organized interviews with some experienced farmers/local village leaders, NGO representatives, market-related stakeholders (potato collector), and experts in government departments.

In this study, collected data in the form of field notes were compiled by the lead researcher into summary tables. Finally, these summary tables were converted to refined tables with concise messages in the form of indicators and short statement (presented in this paper). Indicators and statements are mainly qualitative, supported by some descriptive statistics, i.e., numbers and percentages. In some instances, field stories are presented in detail to explain the local situation in a comprehensive way (see Appendix A Table A2). It is important to mention that findings of this study may only be treated as small evidence from different cropping zones and should not be generalized for other similar areas of the GB province due to its research design based on case studies.

3. Results

3.1. Local Livelihoods

Rahim Abad village accommodates around 400 households. The local people's income sources are diverse, with agriculture remaining the most important source (Table 3). In the village, other income sources include government and private sector jobs, livestock, small businesses, tourism, and remittances. Only 5% of households have sent migrants to other areas for work. In Misgar village, the local people reported that out of total 316 households, only 150 households are currently residing in the village. More than half of the households permanently migrated to urban areas of Gilgit-Baltistan province or other areas of Pakistan. Even among the current resident households, one-fifth have sent one or more migrant members to other areas for income opportunities, leading to labor shortages faced by 10% households in agricultural activities (Table 3). Remittances transferred by out-migrant members are a main income source in the village, followed by another important source—

livestock. Government jobs, agriculture, and tourism are also among income sources in the village.

In Garam Chashma valley, agriculture is considered the most important income source. It contributes around 80% to household income. Other income sources include public and private jobs, small businesses, and remittances. It is important to note that livestock is not reported among key income sources by the local people. In the valley, a very small percentage of households send any household member for the period of six months or more to work. However, during extreme winters when agricultural activities are not possible, around 50% households, for a short period, send one or more members to other areas to work (Table 3). In Mastuj also, agriculture is the most important income source. It contributes 50% of household income. Among other income sources, public and private jobs, livestock, small businesses, and tourisms are reported as key income sources. Only 5% of households have an out-migrant sent to other areas for work (Table 3).

3.2. Food Systems

In Rahim Abad, households have small agricultural landholdings (on average 4–6 kanal). Despite the high importance of local agriculture for household income, it contributes only 30% to overall food requirements in the village. It implies that the village is 70% dependent on external food items for their food security. In agriculture, the production is heavily dependent on traditional irrigation system (locally called *kuhl*). The *kuhl* is fed by two sources of water—springs and glaciers. The village people reported that the share of glacier melt water is larger than that from springs. Among crops, wheat and maize the most important food crops, and fruits are mainly the cash crops in the village. In livestock, cow and goat are considered relatively more important than sheep and poultry. Livestock farmers in the village sell out milk collectively to milk shops in the Gilgit town (daily sale of around 20 L of milk at the rate of Pakistani rupees 80 per liter).

In Misgar, despite not being a significant contributor to household income, agriculture contributes 40% to the local food requirements in the village. The agricultural water requirement is met by solid precipitations and the *kuhl*. The *kuhl* is entirely fed by glacier meltwater only available in the summer. Among crops, potato is the most important crop for both food and cash purposes. In livestock, yak is the most prominent contributor to both food and income of the households in the village (Table 4). The local people reported that around a decade ago, the agriculture was dominated by traditional food crops such as millets, barley, buckwheat, and beans. However, high market value of popular crops (i.e., potato and maize) and changing dietary patterns have resulted in a decline of traditional crops and consequent low dietary diversity (Table 4). They reported that a change in dietary patterns is mainly driven by outmigration. Out-migrants come back to the village occasionally and stay with their relatives. They started introducing new food items and recipes in the village, resulting in a declined preference for traditional food crops in the village over time.

In Garam Chashma valley, farmers have small agricultural landholdings. Agricultural production is heavily dependent on traditional irrigation system (locally known as *gole*) which is fed mainly by the meltwater from glaciers. Overall, agriculture contributes around 40% to local people's food requirements in the valley. In the valley, potato is the most important crop for both food and cash purposes (Table 4). The local people reported a substantial shift from traditional food crops to popular cereals and cash crops. Moreover, a rapid decline in the dietary diversity in food consumption has also been reported (Table 4). Around a decade ago, barley was a major crop, but gradually its importance diminished due to low market value.

Similar to other study areas, agricultural landholdings are small in Mastuj, and the production heavily depends on traditional irrigation systems. Overall, agriculture fulfills around 40% of the total local food requirements (Table 4). In Mastuj, cereals are the most important food crops, and among cash crops, maize, potato, tomato, and fruits are key to household income. In Mastuj also, dietary patterns slightly changed from traditional

food crops to other items. The local people reported that mainly the high market value of other crops such as maize, vegetables (especially off-season), and fruits resulted in the decline of traditional crops. The people also reported that the middleman has a strong role in vegetables and fruits marketing channels with high share in revenue. They come from other areas of Khyber Pakhtunkhwa province and buy products.

Table 4. Agriculture and food security.

Characteristics	Rahim Abad	Misgar	Garam Chashma	Mastuj
Landholding per household (Kanal *)	4–6	5–10	2–5	4–6
Handling of agricultural activities	80% by women 20% by men	95% by women 5% by men	60% by women 40% by men	60% women 40% men
Main food crops	Wheat, maize, potato, beans, and peas	Potato, wheat, peas, and barley	Potato, wheat, maize, barley, and peas	Wheat, barley, maize, vegetables **, and fruits ***
Main cash crops	Apple, apricot, grapes, and cherry	Potato, apricot, and apple	Potato	Maize, potato, tomato, and various fruits
Main livestock	Cow, goat, poultry, and sheep (a few in number)	Yak, sheep, and goat (almost all households have livestock)	Cow, goat, sheep, and poultry	Cow, goat, sheep, and poultry
Markets for agricultural products	Local food processing factory and Gilgit town	Karim Abid, Sost, Aliabad, Gilgit	Chitral town	Mastuj, Buni, and other areas of KPK
Main source of water for agriculture	*Kuhl* system (fed by springs and glacier water)	Solid precipitations and *kuhl* system (fed by glacier water)	*Gole* system and rainfall and solid precipitations	*Gole* system and rainfall and solid precipitations
Labour shortages faced in agriculture and livestock related activities	No	Yes (around 10% households face labor shortage)	No	No
Agricultural diversity	Slight decline	Rapid decline	Rapid decline	Slight decline
Dietary diversity	Slight decline	Rapid decline	Rapid decline	Slight decline
Contribution of local agriculture in annual food requirements	30%	40%	40%	40%

* 20 Kanals = 1 hectare; ** Vegetables include potato, tomato, onion, tomato, okra, beans, peas, turnip, and squashes; *** Fruits include apple, pear, apricot, grapes, peach, cherry, mulberry, and almond. Source: Field notes.

3.3. Women's Role and Youth's Interest in Agriculture

In all the study area, the role of women (mainly above 40 years) in agriculture is increasing. However, they are mainly involved in laborious activities which are likely to increase their workload. In Rahim Abad, around 80% agricultural activities are handled by women. They are engaged in sowing, protecting, weeding, and harvesting of crops. Male household members control the sale and revenue collection of crop products. In Misgar, almost all agricultural activities are handled my women except sale and revenue collection which are controlled by male members (Table 4). In Garam Chashma and Mastuj, around 60% agricultural activities are handled by women. The male members bring inputs, bargain with orchard contractors, and sell the products. They collect revenue and mainly control its use.

In Rahim Abad, almost all households are involved in agriculture and they do not sell agricultural land to the people from outside the village. Elders have high interest in agriculture, but the youth are gradually losing interest in farming, despite it being a profitable source of livelihoods. Similarly, in Misgar, local people reported that youth are losing interest in agriculture due to the limited choices of crops (single cropping zone).

In Mastuj and Garam Chashma, overall, the people have high interest in agriculture. In both sites, the local people reported that the level of youth interest in agriculture is not same as it was a few years back. Their tendency towards non-agricultural income opportunities has increased over time.

3.4. Perceived Climate Change Impacts on Agriculture and Livestock

In study sites, local people reported that they perceive changes in climate compared to the situation of 10 years ago. The people perceived a decline in the average annual volume of precipitations, and a rise in the average temperature of summer seasons and a decline in the average temperature of winter (Table 5). They also perceived an increase in the incidence of erratic event or hazards. In Rahim Abad and Misgar, the people also reported an increase in the incidence of crop pests. In Mastuj, a slight change in the timing of the summer season was reported. The local people reported that summer starts 2–3 weeks early compared to the situation of 10 years ago. Local people's perception of changes in temperature and precipitation are consistent with the climatic data for the period of 2002–2019 derived from locally calibrated South Asian Land Data Assimilation Systems [19]. For all study sites except summer precipitation in Rahim Abad, climatic data showed a declining trend in precipitation (including both rainfall and solid) in both summer and winter. In Rahim Abad, summer precipitation showed an increasing trend. This difference between climatic data and local perception is likely to be due to perceived increase in erratic heavy rainfalls (Table 5) and low frequency of rainfall events. For the study sites, average temperature data for summer showed an increasing trend and for winter it showed a declining trend, which is consistent with local perceptions.

It is interesting that the reported impacts of climate change were mixed—both negative and positive. In Rahim Abad, the people did not perceive any change in the availability of water in *kuhl* which is main source of irrigation for agriculture. They reported an increase in the degradation of pasturelands, resulting in an increased dependency of livestock on cultivated fodder. It is interesting that people reported an increase in the productivity of both crops and livestock compared to 10 years before (Table 5). They believed that changes in temperature have had some positive effects on productivity, but the main influence is caused by an improvement in the supply of seed and inputs and capacity building-training by government and non-government institutions. It has led to a shift from organic to heavily inorganic agricultural practices. The people also reported that climate change-induced increased incidence of fruit fly attacks on fruit orchards is deteriorating the quality of products. It also drives an increased use of pesticides in fruit orchards.

In Misgar, changes in temperature have led to an increased availability of water in *kuhl* due to an increased rate of melting in summer (Table 5). It is important to mention that water is not available in *kuhl* in winter due to frozen water in the system and almost no melting of glaciers. The local people reported that there is only a slight change in the overall productivity of crops. However, they observed a minimal decline in the quality and productivity of vegetables and fruits due to an increased incidence of pest attacks. To cope with increasing pest attacks and improve productivity, farmers have cited the use of pesticides and chemical fertilizers. They did not adequately capitalize on the increased availability of water in agriculture through diversification of crops and improvement of production technology. Local people also reported an increase in the incidence of wildlife attacks (mainly by wolves and snow leopards) on yaks while grazing in pastures. However, they did not attribute this to climate change.

In Garam Chashma and Mastuj, local people reported a decline in the availability of water in *gole* (Table 5). In Garam Chashma, they reported an increase in degradation of pastures, and in Mastuj, an increased incidence of crop pest attacks (i.e., fruit fly) was reported in fruit orchards. In Mastuj, the local people did not observe any notable change in the productivity of crops and livestock. However, in Garam Chashma, the people reported an increase in crop productivity. However, they attributed this positive change to improved seed, fertilizers, and other agronomic practices such as weeding and harvesting.

Table 5. Perception of climate change and its impacts and arising opportunities.

Sites	Perceived Changes in Climate *	Perceived Impacts of Climate Change *	Potentials and Opportunities in Changing Climate
Rahim Abad	• Decline in the quantity of rainfall and solid precipitations • A rise in average summer temperature, decline in average winter temperature • An increase in erratic events (i.e., rainfall and snowfall) • An increase in the incidence of hazards (unexpected heavy snowfall in 2019 and floods and landslides in April 2014 in Rahim Abad; frequent floods in Mastuj in last 5 years) • Early summer in Mastuj and early winter in Rahim Abad	• No change in availability of water in agriculture • Increased incidence of pest attacks in crops (i.e., fruit fly) • Increased crop productivity • Increased degradation of pastures • Increased livestock productivity	• Rising opportunity for growers of fruits and nuts such as cherry, apple, apricot, plum, fig, mulberry, grapes, walnut, and almond due to locally established private fruit processing factory • A potential for crop diversification and livestock integration • Organic fruits production
Misgar		• Increased water availability in *kuhl* system • Increased incidence of pest attacks in crops • Only productivity of some vegetables and fruits is affected by pest attacks • No impact on pasture lands	• Revival of traditional crops to get advantage of agro-ecological conditions and increased water availability • Livestock (i.e., yak) promotion and marketing • Cultivation of vegetables in plastic tunnels • Organic traditional crops and vegetables
Garam Chashma		• Declined availability of water in *goles* (traditional irrigation channels) • Declined vegetation in pastures (i.e., Sobor) • Increased crop productivity	• A huge potential for vegetables production, i.e., tomato, peas, cabbage, cauliflower, and carrot • A potential for fruits, i.e., apple, pear, apricot, mulberry, walnut, and cherry • A potential for traditional crops, i.e., barley and beans, and livestock • Organic vegetables
Mastuj		• Declined water availability for irrigation (both in *goles* and springs) • Increased incidence of pest attacks • Slightly decreased crop productivity	• A potential for sea-buckthorn (medicinal plant) and sinjor (Russian olive) • Various fruits and vegetables • Organic fruits and vegetables

* Perceived changes in climate and its impacts compared to the situation of 10 years ago. Source: Field notes.

3.5. Potentials and Opportunities in Food Systems

Despite some climatic and non-climatic challenges, there are some emerging opportunities to improve agriculture and food security in the study areas. Rahim Abad is located near to Gilgit town, and has good access to market and institutional services, i.e., agricultural extension services by both government and non-government institutions. In this village, agricultural income is mainly dependent on fruits. In the vicinity of this village, a fruits/nuts processing factory has been established which has high demand for locally produced fruits (see S1 in Appendix A Table A2). Local farmers have huge opportunity to enhance their income through improving their fruit production using the organic pest and soil management. Moreover, the village also has potential for various types of vegetables and cereals. While improving fruit production, it is also important to diversify crops to reduce the risks associated with high dependence on one group of products—fruits.

Misgar has high agro-ecological potential for traditional food crops such a millet, barely, beans, and buckwheat. Despite being in a single cropping zone, farmers can take advantage of increased water availability in irrigation systems to revive traditional food crops which are important for improving agrobiodiversity and local dietary diversity. Moreover, the village

also has a scope to further improve their income from livestock raising and cultivation of diverse vegetables in tunnels (see S2 and S3 in Appendix A Table A2; Figures 3 and 4).

Figure 3. Vegetables cultivated in plastic tunnel in Misgar.

Figure 4. A below-surface earthen tunnel for vegetables cultivation in Misgar.

Garam Chashma has high agro-ecological potential for the cultivation of a diverse range of vegetables, fruits, and nuts. However, famers are prioritizing potato cultivation for local consumption and income generation. There is an increased role of middlemen in the marketing channel of potato which is resulting in a decline in farmers' income from potato (see S4 in Appendix A Table A2). Improved institutional services such as credit, agricultural extension services, supply of inputs, and local storage facilities can reduce the role of middlemen and improve farmers' income. In addition, there is dire need to diversify crops to reduce the risk associated with the high dependence on a single crop—potato. Any fluctuation in the price of potato and inaccessibility of the areas caused by climate induced hazard (i.e., flood or landslides) during harvesting time can have serious impacts on farmers' income. Overall, it implies that farmers are highly vulnerable to price shocks and climate-induced hazards. Farmers need to utilize the local agro-ecological potential for diverse vegetables and fruits to reduce their vulnerability. In Mastuj also, local agro-ecological conditions are very suitable to sea-buckthorn, Russian olive, and a diverse range of fruits and vegetables. Local people revealed in SFGDs that they are already generating a good amount of income from fruits. However, there is still a scope for improving production through improved pest management and reducing the role of middlemen.

In all four study sites, farmers have been producing organic products for decades. Discussions with local people and interviews with provincial and district agriculture departments revealed that these study sites have huge potential for organic production. Farmers reported that they can shift back to organic practices if their capacity in organic pest management and soil nutrient conservation are developed, and improved varieties of traditional crops, vegetables, and fruits are introduced in the areas for improving their productivity. Their main concerns in organic farming included low productivity and increased incidence of pest attacks especially on fruits.

4. Discussions

In the high-altitude mountain areas of Pakistan, historically local agriculture has been a major contributor to local food consumption. Over time, the contribution of agriculture has declined significantly [7,29,30]. In study sites, local people reported that currently, local agriculture contributes around 30–40% food to annual food requirements (Table 4). This implies that local people's dependence on external food items has increased, leading to a decline in local agricultural and dietary diversities, as reported in previous studies on other mountain regions [30,31]. Particularly, traditional food crops, i.e., barley, millets, and beans are gradually disappearing from the agricultural systems. In Misgar (single cropping zone), the influence of out-migrants on local diets and low market value of traditional crops, i.e., buckwheat, barley, and millets, are two major factors of declining agricultural and dietary diversities. The local village leader also reported that the government's subsidies on wheat (supplied from plains) is also an important factor which triggered the disappearance of traditional crops from the village. The people prefer to buy subsidized food rather than growing locally. It has also been reported that women's role in agriculture has significantly increased. They carry out most of the agricultural practices but have almost no control over financial retunes from agriculture.

In terms of income contributions, agriculture still remains an important source of livelihood in three study sites, i.e., Rahim Abad, Garam Chashma, and Mastuj. There is negligible shift from agriculture to non-agriculture income sources in these areas (Table 3). In Misgar, remittances and livestock are two leading income sources (Table 3), and there is a clear shift from agriculture to non-agricultural income sources due to harsh climatic conditions (i.e., snow cover for 6 months in winter) and rampant outmigration of young population. This is consistent with findings of other studies from similar high mountain areas in Pakistan [1,7]. Among several factors, limited income opportunities are the most important factor in Misgar for high out-migration rate, as reported by local people. Moreover, due to the outmigration of active young people, local people also face labor shortages in agricultural and livestock related activities (Table 3), as reported elsewhere [12,32,33].

Similar to other high-altitude mountain areas [12,34,35], local people perceived changes in the climate (compared to 10 years ago situation), and reported its mixed impacts (both positive and negative) on agriculture and food security in the study sites. In high altitude mountain areas, nature of climate change impacts may vary from one area to another, even within the same region, depending on the nature of changes in climate and types of crops [13–15]. In Rahim Abad, local people perceived that the incidence of pest attacks has negative and changes in temperature have positive impact on crop production. Overall, crop productivity has increased over time in the changing climate. This increase was not only attributed to climate change. They also attributed it to other factors such as enhanced use of pesticides and inorganic fertilizers, and farm management capacity enhanced by NGOs and government departments. It is important to understand that the increase in pesticides use is indirectly related to climate change because local people attributed the increased pest attacks to climate change. Climate change also accelerated the degradation of pasturelands, leading to high dependency of livestock on cultivated fodder. Interestingly, this increased use of fodder and improved agricultural extension services resulted in improved livestock productivity. In Misgar, production of some vegetables and fruits is affected by an increased incidence of pest attacks. In Garam Chashma, despite a decline in

water availability for irrigation, crop productivity increased over time. The local people mainly attributed it to improved access to high yielding seed, changes in temperature, and a significant rise in the use of inorganic fertilizers and pesticides, particularly in the case of potato. In Mastuj, a decline in water availability for irrigation and an increased pest attacks on crops resulted in a slight decline in crop productivity, particularly in fruits and vegetables. Findings on an increased incidence of pest attacks in study sites and its negative impacts on agriculture are consistent with preceding studies from similar mountain areas [35,36].

In the changing food systems, some opportunities also need to be realized by local people for long term development and sustainability in the agriculture. It has been observed that agriculture is shifting from organic to inorganic practices. During data collection, the government officials, local people, and the representatives of NGOs revealed that all study sites have a huge potential for organic products but they are underutilizing this potential to gain short-term benefits of productivity and income. Capacity building of farmers on organic integrated pest management, soil nutrient conservation, compost preparation, and value chains and branding of organic products can help utilize the potential of organic farming in the study sites, as reported elsewhere [37,38].

Documented stories from study sites (see Appendix A Table A2) revealed local communities' autonomous adaptations to climatic and non-climatic changes. There are some risks involved in such adaptations which need to be addressed adequately. Value chain development and commercialization of some agricultural products is important for income improvement, but it should not be at the cost of diversity and sustainability of the production systems. In Rahim Abad and Garam Chashma, farmers are benefitting, respectively, from the cultivation of fruits and potato. In fact, they are also increasing their vulnerability to market and climatic shocks. Any unexpected price fluctuation of these products and climatic or natural phenomena in the area may lead to serious impacts on local livelihoods and sustainability of food systems. In Misgar, a local farmer successfully experimented with vegetable cultivation in plastic and below-surface earthen tunnels to showcase the potential of the area in vegetables production. However, the potential for traditional crops and yak is still underutilized in this village. A support mechanism for the revival of traditional crops and value chains of yak, fruits, nuts, and vegetables can not only improve farmers' income but will also lead to improved agro-biodiversity and sustainability of the local food systems [16,39–46].

5. Conclusions and a Way Forward

In the Hindu Kush Karakoram Pamir Landscape (HKPL), traditionally, local agriculture and livestock have been major contributors to local food consumption in the landscape. However, their contribution has gradually declined due to a decline in local agricultural diversity and increased preference of the local people for external food items. The role of women in agriculture has also increased significantly. Despite handling most of the agricultural activities, they almost have no control over agricultural income.

In Rahim Abad, Garam Chashma, and Mastuj, agriculture is still profitable and considered as the most important income source. Local people are still interested in continuing farming and there is negligible shift of local people from agriculture to non-agricultural income sources. In Misgar, local people's preference has clearly shifted from agriculture to livestock and non-agricultural income opportunities such as outmigration. In study sites, local people perceived changes in climate and reported its mixed impacts (both positive and negative) on agriculture and food security with variation in magnitude. An increased incidence of pest attacks, attributed to climate change, has had a negative impact on crop productivity. However, climate change together with enhanced use of pesticides and inorganic fertilizers, improved seed, and improved farm management have had a positive influence of crop productivity. It is also evident that an increase in pesticide use is indirectly related to climate change.

In food systems of study sites, some opportunities are also emerging which need to be capitalized on for sustainability in food systems. Study sites have a huge potential

for organic production which is being ruined by increasing inorganic practices. Capacity building of farmers on organic integrated pest management, soil nutrient conservation, compost preparation, value chain development, and branding of organic products can help utilizing the organic production potential in the study sites.

There is a need for adequate integration of livestock (i.e., yak, sheep, and goats) and increasing the crop diversity through revival of traditional food crops, medicinal plants (i.e., sea-buckthorn), and cultivation of neglected vegetables, fruits, and nuts. Protected cultivation (i.e., in plastic tunnels) of vegetables even in high-altitude areas with harsh climate like Misgar may also be strengthened without impacting crop diversity.

In all study sites, any storage facilities may also help in utilizing the maximum potential of agriculture through reducing the post-harvest losses and limiting the increasing role of middlemen particularly in Garam Chashma and Mastuj.

There is also a need for increasing awareness about the role of diversities in agriculture and diets for sustainability in food systems and nutrition security. More emphasis is required on an integrated approach in research and policies covering both nutrition security and best practices for mountains agriculture.

Non-agricultural activities such as tourisms and small businesses are equally important for local economy and food security. However, a rapid shift from agricultural to non-agriculture activities will further marginalize the local agriculture (crops and livestock). There is need to link both agricultural and non-agricultural activities for mutual benefits. For example, mechanism for agro-tourism may be established, and food products prepared from traditional crops and native livestock may be promoted in tourist attraction places and local resorts and restaurants.

Last but not least, women need to be given managerial roles with control over financial returns in agriculture and livestock farming. Currently, they are more involved in labor activities which has added to their workload.

Author Contributions: A.H. conceptualized the research, collected and analyzed data, and drafted and revised the manuscript. F.M.Q. contributed to conceptualization, analysis, and writing. L.A. reviewed the literature and contributed to the write-up of the manuscript. A.I.H. and A.u.R. contributed to data collection and analysis. K.B. contributed to research conceptualization and manuscript writing. All authors have read and agreed to the published version of the manuscript.

Funding: Financial support (including article processing charges) for this study was mainly provided by the Hindu Kush Karakoram Pamir Landscape (HKPL) Initiative of ICIMOD, which is implemented in four countries, i.e., Afghanistan, China, Pakistan, and Tajikistan. The study was also partly supported by funds from the Resilient Mountain Solutions (RMS) Initiative of ICIMOD. This initiative is funded by governments of Sweden and Norway.

Institutional Review Board Statement: This manuscript was approved (approval # 1098) by the Publications and Outreach (POUT) committee of the International Centre for Integrated Mountain Development (ICIMOD).

Informed Consent Statement: Before starting the interviews, verbal consent from all participants (local community and key informants) was taken to use the collected information/data for research purposes.

Data Availability Statement: This research is mainly based on qualitative data which were collected in the form of field notes. Hard copies of field notes are available with Abid Hussain (corresponding author). He can be reached to procure data for research and academic purposes.

Acknowledgments: Authors would like to thank two anonymous reviews for their highly constructive input to improve the quality of this article. They are also thankful to all participants (local community and key informants) of this research for their support during data collection process. The views and interpretations expressed in this publication are those of the authors and are not necessarily attributable to ICIMOD. The authors also gratefully acknowledge the support of core donors of ICIMOD: the Governments of Afghanistan, Australia, Austria, Bangladesh, Bhutan, China, India, Myanmar, Nepal, Norway, Pakistan, Switzerland, and the United Kingdom.

Conflicts of Interest: The authors declare no conflict of interest.

Appendix A

Table A1. Coordination schema. Unit of analysis: village level.

Aims	Broad Aspects	Required Information	Source of Information	Data Collection Tool
Basic information	• Biophysical and climatic characteristics • Socioeconomic characteristics • Livelihood sources and patterns	• Village altitude • Average temperature and precipitation in summer and winter • Average household size • Main income sources • Migration trends • Any shifts/changes in livelihood sources	• Local community in the village	• Slow focus group discussions (SFGDs) • Non-structured interviews with key informants (i.e., experienced farmer/village leader) • Reports/journal articles (for additional climatic information only)
Status of food systems	• Scale of farming • Crop calendar • Main crops and livestock • Water availability for crops and livestock • Changes in agricultural systems • Dietary diversity and food consumption	• Cropping zone • Agricultural landholding size • Main food and cash crops • Main livestock types • Market hubs for agricultural products (both crops and livestock) • Main water sources for crops and livestock • Irrigation systems (if available) • Key changes in food systems (i.e., labor availability, women's role, organic vs. inorganic farming, agricultural diversity, etc.) • Any impacts of outmigration on local food systems • Contribution of local agriculture (crops and livestock) in food consumption • Dietary diversity of local people	• Local community in the village	• Slow focus group discussions (SFGDs) • Non-structured Interviews with key informants (i.e., experienced farmer/village leader) • Field observation

Table A1. *Cont.*

Aims	Broad Aspects	Required Information	Source of Information	Data Collection Tool
Local perception of climate change and its impacts (any changes observed in recent times compared with the situation of 10 years ago—2009 or earlier)	• Perception of changes in temperature and precipitation in summer and winter • Incidence of climate change induced erratic events and hazards • Impacts of climate change on crops, pastures/rangelands, and livestock productivity	• Change in average temperature in summer and winter • Change in annual precipitation (rainfall and solid) • Impact on water availability in irrigation systems • Change in the incidence of heavy precipitation, floods, dry spells, landslides, avalanches etc.) • Change in the incidences of crop pest attacks and livestock diseases • Change in the productivity of crops, pastures/rangelands, and livestock • Any other key aspects (if emerges during interviews)	• Local community in the village	• Slow focus group discussions
Potentials and emerging opportunities in changing climate	• Identification of local potentials and emerging opportunities to cope with climate change induced impacts on food systems • Identification of any risks	• Collecting success stories and identifying risks from the field • Getting expert opinion from key local stakeholders	• Local community • Key experts	• Non-structured interviews with key informants (i.e., experienced farmer/village leader and market-related stakeholder, NGO representative, and experts in agriculture department

Table A2. Stories from the field.

Story	Details	Information Source
S1. Fruit/nuts processing factory in Rahim Abad (risks involved: shift from diverse cropping systems to fruits, and organic to inorganic practices)	In 2008, a fruit processing factory was established in the vicinity of Rahim Abad village based on the potential of the area for fruits production. The factory main processes multiple fruits such as apricot, apple, mulberry, plum, fig, walnut, cherry, and grapes. With the passage of time, it increased its production scale, resulting in a gap between supply (by local farmers) and demand (by factory) of raw fruits. To fill this gap, the factory started buying fruits from other areas of Gilgit-Baltistan (GB) province and Chitral region in Khyber Pakhtunkhwa province. The manager of the factory reported that there is still a scope to expand the production of processed items, but they face mainly two constrains. First, local fruit supply is not improving and buying fruits from other areas incur higher transportation cost. Second, the operational area of the factory is small, and they need more land and machinery to expand it. However, they can invest in additional land and machinery if local fruit supply improves sustainably. The factory operates all year, and produces jam, juices, and kilau (a traditional product prepared from walnut and the pulp of fruits such as apricot, mulberry and grapes). Processed food items are mainly supplied to all areas of GB, but also occasionally supplied to downstream areas. The factory manager reported they are not able (supply is less) to meet the high demand for the food items is the market. This implies that they produce good quality food items. Based on the data provided for the year 2018, the estimated annual revenue of the factory was PKR 12.4 million (excluding family labor), and the total incurred annual cost was PKR 7.5 million. This reveals that the factory earned profit of 4.9 million in a year. Importantly, this unit employed 30 people including laborers and technicians, and paid salaries around 2.3 million.	Interview with the manager of fruit/nuts processing factory SFGD with local community
S2. Yak management in Misgar	In Misgar, yak (including bua—local term for female yak) is one of the most important income food and income source for the local people. It mainly depends on pasturelands (i.e., Kilik, Mintika, Dilsan) for grazing. A few years back, the villagers had around 40 yaks, and they formed a cooperative type of management system for yaks. At present, they have 172 yaks (as of November 2019) managed by the cooperative. To start the cooperative, livestock raising households contributed money ranging from PKR10,000–63,000. Based on the share of households, every year they distribute the profit among themselves. To take care of yaks in the pastures, two full time herders are hired with monthly salary PKR25,000 per herder. Main yak products sold locally and in nearby markets include milk, meat, butter, ghee, and skin. Food products of yak are also extremely important for local food security in the village.	SFGD with local community Interview with key informant (community representative)
S3. Vegetables cultivation in tunnels in Misgar	A couple of years ago, a farmer, Mr. Sehat Rahim, experimented with the cultivation of organic vegetables in a plastic tunnel during snowfall period and summer as well (see Figure 3). Now, he is successfully growing tomato, cabbage, carrot, cauliflower, and some other vegetables. His vegetables in plastic tunnel are highly demanded during winter when market access is constrained by blocked roads to due to snowfall. He recently also experimented with the cultivation of organic vegetables, particularly cabbage, in a below-surface earthen tunnel. He arranged light in the tunnel using the slower panels (see Figure 4).	SFGD with local community Interview with key informant (community representative)

Table A2. *Cont.*

Story	Details	Information Source
S4. Role of middleman in potato marketing in Garam Chashma(risks involved: shift from diverse cropping systems to only potato, and high control of middleman in marketing channel)	Garam Chashma valley has huge potential for the production of potato and other vegetables. However, the farmers are prioritizing potato cultivation due to its high demand in downstream areas. Currently, potato is the main food as well as cash crop. Farmers have gradually started the use of inorganic fertilizers in potato production. Inorganic fertilizers and seed (price: PKR 25/kg) are mainly provided on credit (in kind) by the external middlemen coming from plain areas, particularly Gujranwala, Punjab province. Due to this informal in-kind credit and lack of local storage facilities, most of the farmers sell their produce to the middlemen who purchase potato at the price of PKR 30–40/kg. In the retail markets of the Punjab, this transported potato is sold at the price of PKR 70–100/kg. Taking into account the median values of purchasing and selling prices, it is estimated that farmers only get 41% share of the selling price, and 47% is obtained by different middlemen at different levels. Transportation and handling costs account for 12% of the selling price. Farmers reported that the production of potato incurs the cost of PKR15–18/kg. This implies that they earn profit of PKR 17–20/kg in potato production.	SFGD with local community Interview with NGO representative Local potato collector (middleman)

Note: PKR 155.7 = 1 USD (on 31 October 2019). Unit of analysis: village level.

References

1. Rasul, G.; Saboor, A.; Tiwari, P.C.; Hussain, A.; Ghosh, N.; Chettri, G.B. Food and Nutrition Security in the Hindu Kush Himalaya: Unique Challenges and Niche Opportunities. In *The Hindu Kush Himalaya Assessment*; Springer: Cham, Switzerland, 2019; pp. 301–338.
2. Dame, J.; Nusser, M. Food security in high mountain regions: Agricultural production and the impact of food subsidies in Ladakh, Northern India. *Food Secur.* **2011**, *3*, 179–194. [CrossRef]
3. Gautam, Y.; Andersen, P. Multiple stressors, food system vulnerability and food insecurity in Humla, Nepal. *Reg. Environ. Chang.* **2017**, *17*, 1493–1504. [CrossRef]
4. Jaquet, S.; Schwilch, G.; Hartung-Hofmann, F.; Adhikari, A.; Sudmeier-Rieux, K.; Shrestha, G.; Liniger, H.; Kohler, T. Does outmigration lead to land degradation? Labour shortage and land management in a western Nepal watershed. *Appl. Geogr.* **2015**, *62*, 157–170. [CrossRef]
5. ICIMOD. *Food Security in the Hindu Kush Himalayan Region*; Position Paper; ICIMOD: Kathmandu, Nepal, 2008.
6. Hussain, A.; Routray, J.K. Status and factors of food security in Pakistan. *Int. J. Dev. Issues* **2012**, *11*, 164–185. [CrossRef]
7. Hussain, A.; Rasul, G.; Mahapatra, B.; Tuladhar, S. Household food security in the face of climate change in the Hindu-Kush Himalayan region. *Food Secur.* **2016**, *8*, 921–937. [CrossRef]
8. IPC. *Afghanistan: IPC Acute Food Insecurity Analysis (August 2018–February 2019)*; Integrated Food Security Phase Classification (IPC) Regional Office: Bangkok, Thailand, 2019.
9. FSA. *Food Insecurity in Pakistan*; Food Security Analysis (FSA); Sustainable Development Policy Institute (SDPI): Islamabad, Pakistan, 2009.
10. World Bank. *Childhood Stunting in Tajikistan: Quantifying the Association with WASH Food Security, Health and Care Practices*; Discussion Paper; The World Bank: Washington, DC, USA, 2017.
11. WFP. *Climate Risks and Food Security in Tajikistan: A Review of Evidence and Priorities for Adaptation Strategies*; World Food Programme: Rome, Italy, 2017.
12. Hussain, A.; Mahapatra, B.; Rasul, G. Adaptation in Mountain Agriculture: Food Security in the Hindu-Kush Himalayan (HKH) Region. In *Status of Climate Change Adaptation in Asia and the Pacific*; Springer: Cham, Switzerland, 2019; pp. 211–236.
13. Hashmi, A.A.; Shafiullah, A. Agriculture and Food Security. In *Planning & Development Department, Northern Areas (Pakistan)*; IUCN: Sindh, Pakistan, 2003.
14. Abbasi, S.S.; Ahmad, B.; Ali, M.; Anwar, M.Z.; Dahri, Z.H.; Habib, N.; Hussain, A.; Iqbal, B.; Ishaq, S.; Mustafa, N.; et al. *The Indus Basin: A Glacier-Fed Lifeline for Pakistan*; HI-AWARE Working Paper 11; HI-AWARE: Kathmandu, Nepal, 2017.
15. Mishra, A.; Hussain, A.; Rasul, G. Climate change haunts South Asian livelihoods. *Trade Insight* **2016**, *12*, 10–13.
16. Rasul, G.; Hussain, A.; Khan, M.A.; Ahmad, F.; Jasra, A.W. *Towards a Framework for Achieving Food Security in the Mountains of Pakistan*; ICIMOD Working Paper 2014/5; ICIMOD: Kathmandu, Nepal, 2014.
17. Hussain, A.; Fisher, D.; Espiner, S. Transport Infrastructure and Social Inclusion: A Case Study of Tourism in the Region of Gilgit-Baltistan. *Soc. Incl.* **2017**, *5*, 196–208. [CrossRef]
18. Government of Gilgit-Baltistan. *Major Agro-Ecological Zones of Gilgit-Baltistan*; Department of Agriculture, Government of Gilgit-Baltistan: Gilgit-Baltistan, Pakistan, 2013.
19. Zhou, Y.; Zaitchik, B.F.; Kumar, S.V.; Arsenault, K.R.; Matin, M.A.; Qamer, F.M.; Zamora, R.A.; Shakya, K. Developing a hydrological monitoring and sub-seasonal to seasonal forecasting system for South and Southeast Asian river basins. *Hydrol. Earth Syst. Sci.* **2021**, *25*, 41–61. [CrossRef]
20. Mills, M.C.; Given, L. Comparative Research. In *The SAGE Encyclopedia of Qualitative Research Methods*; SAGE Publications Pvt Ltd.: Thousand Oaks, CA, USA, 2008; Volume 1, pp. 68–71.
21. Dul, J.; Hak, T. *Case Study Methodology in Business Research*; Routledge: London, UK, 2007.
22. Bryman, A.; Bell, E. *Business Research Methods*, 2nd ed.; Oxford University Press: Oxford, UK, 2007.
23. Eriksson, P.; Kovalainen, A. Research philosophy. *Qual. Methods Bus. Res.* **2008**. [CrossRef]
24. Saunders, M.N.K.; Lewis, P.; Thornhill, A. *Research Methods for Business Students*, 4th ed.; Prentice Hall: New York, NY, USA, 2007.
25. Ćwiklicki, M.; Pilch, K. Multiple case study design: The example of place marketing research. *Place Brand. Public Dipl.* **2020**, 1–13. [CrossRef]
26. Jentoft, N.; Olsen, T.S. Against the flow in data collection: How data triangulation combined with a 'slow' interview technique enriches data. *Qual. Soc. Work. Res. Pract.* **2017**, *18*, 179–193. [CrossRef]
27. Young, C.; Zubrzycki, J.; Plath, D. The slow interview? Developing key principles and practices. *Qual. Res.* **2020**, 1468794120935300. [CrossRef]
28. Merrey, D.J.; Hussain, A.; Tamang, D.D.; Thapa, B.; Prakash, A. Evolving high altitude livelihoods and climate change: A study from Rasuwa District, Nepal. *Food Secur.* **2018**, *10*, 1055–1071. [CrossRef]
29. WFP. Climate Risks and Food Security Analysis: A Special Report for Pakistan. 2018. Available online: https://reliefweb.int/sites/reliefweb.int/files/resources/Climate_Risks_and_Food_Security_Analysis_December_2018.pdf (accessed on 20 September 2020).

30. Spies, M. Changing Food Systems and Their Resilience in the Karakoram Mountains of Northern Pakistan: A Case Study of Nagar. *Mt. Res. Dev.* **2018**, *38*, 299–310. [CrossRef]
31. Rasul, G.; Hussain, A.; Mahapatra, B.; Dangol, N. Food and nutrition security in the Hindu Kush Himalayan region. *J. Sci. Food Agric.* **2018**, *98*, 429–438. [CrossRef] [PubMed]
32. McLeman, R. Migration and Land Degradation: Recent Experience and Future Trends. Global Land Outlook. *Working Paper.* 2017. Available online: https://knowledge.unccd.int/sites/default/files/2018-06/8.%20Migration%2Band%2BLand%2BDegradation__R_McLeman.pdf (accessed on 25 September 2020).
33. FAO. *Mountain Agriculture: Opportunities for Harnessing Zero Hunger in Asia*; FAO: Bangkok, Thailand, 2019.
34. Spies, M. Mixed manifestations of climate change in high mountains: Insights from a farming community in northern Pakistan. *Clim. Dev.* **2020**, *12*, 911–922. [CrossRef]
35. Bhatta, L.D.; Udas, E.; Khan, B.; Ajmal, A.; Amir, R.; Ranabhat, S. Local knowledge based perceptions on climate change and its impacts in the Rakaposhi valley of Gilgit-Baltistan, Pakistan. *Int. J. Clim. Chang. Strat. Manag.* **2019**, *12*, 222–237. [CrossRef]
36. Abbas, A.; Syed, S.A.; Moosa, A. Emerging plant diseases of Gilgit-Baltistan (GB) Pakistan: A review. *Agric. Res. Technol.* **2018**, *18*, 1–6.
37. CABI. CASE Study: Agricultural Training for Pakistan's Rural Women. Available online: https://platform.cabi.org/Uploads/CABI/long-case-studies/Agricultural%20Training%20For%20Pakistans%20Rural%20Women.pdf (accessed on 25 September 2020).
38. Khan, F.; Khan, T.U.; Ayub, M.; Kabir, R. Demonstration of Technologies and Training of Growers for Handling and Value Addition of Fruits and Vegetables in Gilgit-Baltistan. *Adv. Food Technol. Nutr. Sci. Open J.* **2019**, *5*, 67–72. [CrossRef]
39. Adhikari, L.; Hussain, A.; Rasul, G. Tapping the Potential of Neglected and Underutilized Food Crops for Sustainable Nutrition Security in the Mountains of Pakistan and Nepal. *Sustainability* **2017**, *9*, 291. [CrossRef]
40. Adhikari, L.; Tuladhar, S.; Hussain, A.; Aryal, K. Are Traditional Food Crops Really 'Future Smart Foods?' A Sustainability Perspective. *Sustainability* **2019**, *11*, 5236. [CrossRef]
41. Atreya, P.; Kafle, A. Production practice, market and value chain study of organic apple of Jumla. *J. Agric. Environ.* **2018**, *17*, 11–23. [CrossRef]
42. Gauchan, D.; Bhandari, B.; Gurung, R.; Joshi, B.K.; Paudel, M.N.; Jarvis, D. Value Chain Development of Underutilized Food Crops for Nutrition Sensitive Agriculture in the Mountains of Nepal. Conference Paper. 2019. Available online: https://www.researchgate.net/publication/333672594_Value_Chain_Development_of_NUS_for_nutrition_sensitive_agriculture_in_the_mountains_of_Nepal (accessed on 15 September 2020).
43. Hussain, A.; Rasul, G.; Mahapatra, B.; Wahid, S.; Tuladhar, S. Climate change-induced hazards and local adaptations in agriculture: A study from Koshi River Basin, Nepal. *Nat. Hazards* **2018**, *91*, 1365–1383. [CrossRef]
44. Hussain, A.; Choudhury, D.; Mishra, A. Will a Hunger Pandemic Follow in Mountains? A Blog at ICIMOD Website. 2020. Available online: https://www.icimod.org/article/will-a-hunger-pandemic-follow-in-the-mountains/ (accessed on 12 September 2020).
45. Thapa, S.; Hussain, A. Climate change and high-altitude food security: A small-scale study from the Karnali region in Nepal. *Clim. Dev.* **2020**, *31*, 1–2. [CrossRef]
46. ICIMOD. *COVID-19 Impact and Policy Responses in the Hindu Kush Himalaya*; International Centre for Integrated Mountain Development: Lalitpur, Nepal, 2020.