Community Resilience and Innovation in Livelihood Strategies: Exploring the Drivers of Change in Mountain Agriculture in Lotkuh Valley, Pakistan

Zahir Ahmad[1], Sher Muhammad Malik[2], Mehran[3], Kamal Hussain[4], Noor ul Haq[5], and Farhana Altaf [6]

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Abstract

Mountain agriculture is the linchpin of the economy in Pakistan's Hindu Kush Karakoram and Himalaya mountain regions. Currently, mountain agriculture is in a state of transition, experiencing rapid changes and innovation due to physical and anthropogenic drivers, resulting in far-reaching consequences on the livelihood sustainability and food security of the local people. This study explores the multifaceted drivers of agricultural transformation in the Eastern Hindu Kush region, specifically in Lotkuh Valley, Pakistan, focusing on the intricate relationship between resilience-building measures and the adoption of innovative agricultural practices. For this purpose, data were explored from both primary and secondary sources. Primary data were collected using stratified sampling techniques during extensive field surveys conducted in the study area from 2017 to 2019. Remotely sensed data from 1990 to 2019 were obtained from the USGS site. Secondary data were acquired from the Gazetteer of Chitral 1928, Census Report 1961-2017, and Rural Settlement Report 1988. The collected data have been analyzed through descriptive analysis and advanced geospatial techniques. The findings reveal that vivid changes and transformations have occurred in mountain agriculture. These transformations include land use/cover changes, agricultural land holdings, cropping patterns, livestock populations, arboriculture, etc. From the findings of this study, it is inferred that innovation in mountain agriculture entails a variety of opportunities and has increased agricultural production, resulting in a positive impact on the economy, food security, and livelihood sustainability. This study provides nuanced knowledge and insights for policymakers, mountain agriculturists, and practitioners to effectively develop sophisticated strategies for achieving the ambitious goal of zero hunger and poverty eradication.

Keywords: Mountain agriculture, Food security, Accessibility, Livelihood, Lotkuh, Chitral.

Introduction

Worldwide, mountain agriculture is crucial for food security and the sustainability of livelihoods in mountain regions. It provides high-quality alpine food products (Dach et al., 2014) and serves as a custodian of traditional landscapes, regional breeds, and species. It

[1]*Lecturer, Department of Geography, The Islamia University of Bahawalpur, Pakistan.*
Email: Zahir.ahmad@iub.edu.pk
[2]*Professor & Chairman, Department of Geography, The Islamia University of Bahawalpur.*
Email: sher.malik@iub.edu.pk.
[3]*Lecturer, Department of Geography, Islamia College Peshawar. Email: Mehran@icp.edu.pk*
[4]*Assistant Professor, Department of Geography, Shah Abdul Latif University Khairpur, Sindh.*
Email: hussain.kamal@salu.edu.pk
[5]*PhD Scholar, Department of Geography and Geomatics, University of Peshawar, Pakistan.*
Email: noor.geography@gmail.com
[6]*MPhil Scholar, Department of Geography, The Islamia University of Bahawalpur, Pakistan*
Email: farhana786altaf@gmail.com

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represents cultural ecosystem services and safeguards historical heritage and traditional techniques (Ahmad, 2021). Additionally, it plays a pivotal role in preserving local culture and heritage (FAO, 2019). However, mountain agriculture is currently highly sensitive and susceptible to change, rendering it vulnerable to degradation and unsustainable in the Hindu Kush Karakoram Himalaya (HKH), resulting in far-reaching consequences. For the last three decades, changes in mountain agriculture and its associated pros and cons have become the subject of interest for researchers in mountain regions (Burris, 2015; Choenkwan et al., 2014; Rana et al., 2021; Ahmad, 2021). Globally, mountain agriculture is transitioning, and several ecosystems are shifting due to coupled physical and socio-economic drivers of changes. Generally, the inhabitants of mountain regions are poor and marginalized. On average, one in eight persons is food insecure, but in rural mountain areas, this ratio is one in two (FAO, 2019). Nevertheless, this ratio is more critical in the HKH region of Pakistan.

Mountain agriculture is the lynchpin of the economy and the most crucial livelihood activity in developed and developing countries (Choenkwan et al., 2014; Tzanopoulos et al., 2011). The salient traits of mountain agriculture are pretty similar throughout the mountainous regions of the world (Bernues et al., 2011; Dame & Nüsser, 2011; MacDonald et al., 2000; Partap, 1999, 2011; Tulachan, 2000; Zimmerer, 1999). Whereby irrigated cultivation and animal husbandry are interdependent and integrated (Potthoff, 2007; Schmidt, 2004), and usually extend over different altitudinal belts and have a symbiotic relationship (Ehlers & Kreutzmann, 2000). It is also characterized by and associated with the movement of people and animals in vertical space, communal control of pastures combined with individual control of fields and social institutions that schedule the intricate movements in time and space (Ahmad et al., 2021; Ehlers, 2008).

The Hindu-Kush-Karakorum-Himalayan region of Pakistan is ecologically fragile, tectonically and seismically active, geologically unstable, economically backward, and geographically remote (Ahmad et al., 2022; Ahmad, 2021). Although agriculture and its allied activities are mountain inhabitants' main occupations but cereal crops' production and yield are significantly low and need more for the whole season. Therefore, mountain inhabitants combine a diverse set of on-farm and off-farm income-generating activities and construct a portfolio of livelihood activities (Fang et al., 2014; Khatiwada et al., 2017) as a viable economic strategy for livelihood sustenance and to avoid risk, maximize self-sufficiency and minimize seasonality (Ahmad, 2014; 2021). The livelihood strategies of the mountain inhabitants are highly dynamic, and new services are added in the domain of the livelihood strategies. The main livelihood components include farming, livestock rearing, wage labor, government and private services, business, and remittances from abroad (Rahut et al., 2012; Kreutzmann, 2020).

For centuries, subsistence-based mountain agriculture was the economic mainstay of mountain inhabitants, and people lived to a high degree of self-sufficiency through well-adjusted mountain agriculture. However, it has witnessed an accelerated change recently due to explosive population growth, improved accessibility, and rising demand for food (Rahman, 2007, 2009; Hussain, et al., 2022). Major agricultural dynamics such as changes in cropping pattern and type (Tulachan, 2001), agricultural input (Nüsser, 1998), heavy dependency on market for food and fodder, change in livestock population and composition (Nüsser et al., 2012), decline of high pasturing and pasture products (Fischer, 2000) and diversification of division of labor (Kreutzmann, 2000) have been occurred in the socio-ecological set up of mountain agriculture. The impacts of agriculture transformations on livelihood strategies are substantial. On the one hand, modernization of agriculture entails a variety of opportunities and increased agricultural production. On the other hand, this revolution has resulted in several harmful impacts. Scientific studies have indicated that the environmental conditions of mountain areas in many parts of the HKH region are deteriorating due to agricultural transformation. Thus, mountain agriculture is becoming unsustainable and leading to risk (Bohle, 1998: p. 227). Despite the considerable importance of mountain agriculture, a conspicuous research gap exists in the domain of agricultural transformation within the Eastern

Hindu Kush (EHK) region. However, studies have not been conducted on the mountain agricultural transformation in the Eastern Hindu Kush. A comprehensive study has yet to investigate the causes of agricultural transformation in this high mountain region.

Lotkuh Valley, located in the EHK, is the best representative of the mountain region for studying changes in mountain agriculture. It is located on the periphery of district Chitral (Lower) and close to the Wakhan Corridor. The study area is highly rugged and surrounded by 6000m to more than 7000m high ranges of the Hindu Kush. Interrupting these mountain systems, there are deep, narrow, and tortuous valleys where farming is practiced in small alluvial fans and talus creeps. Due to topographic constraints, the double cropping zone is minimal and confined to the central valley and sub-valleys up to 2200 meters above mean sea level (a.s.l.), while more than 95% of the study area is located in the single cropping zone. Most inhabitants are directly engaged in agricultural activities for livelihood security and sustenance. Over the last three decades, this valley has witnessed abrupt and palpable changes. This study explores the driving forces and impacts of mountain agricultural transformation on livelihood strategies in the Eastern Hindu Kush.

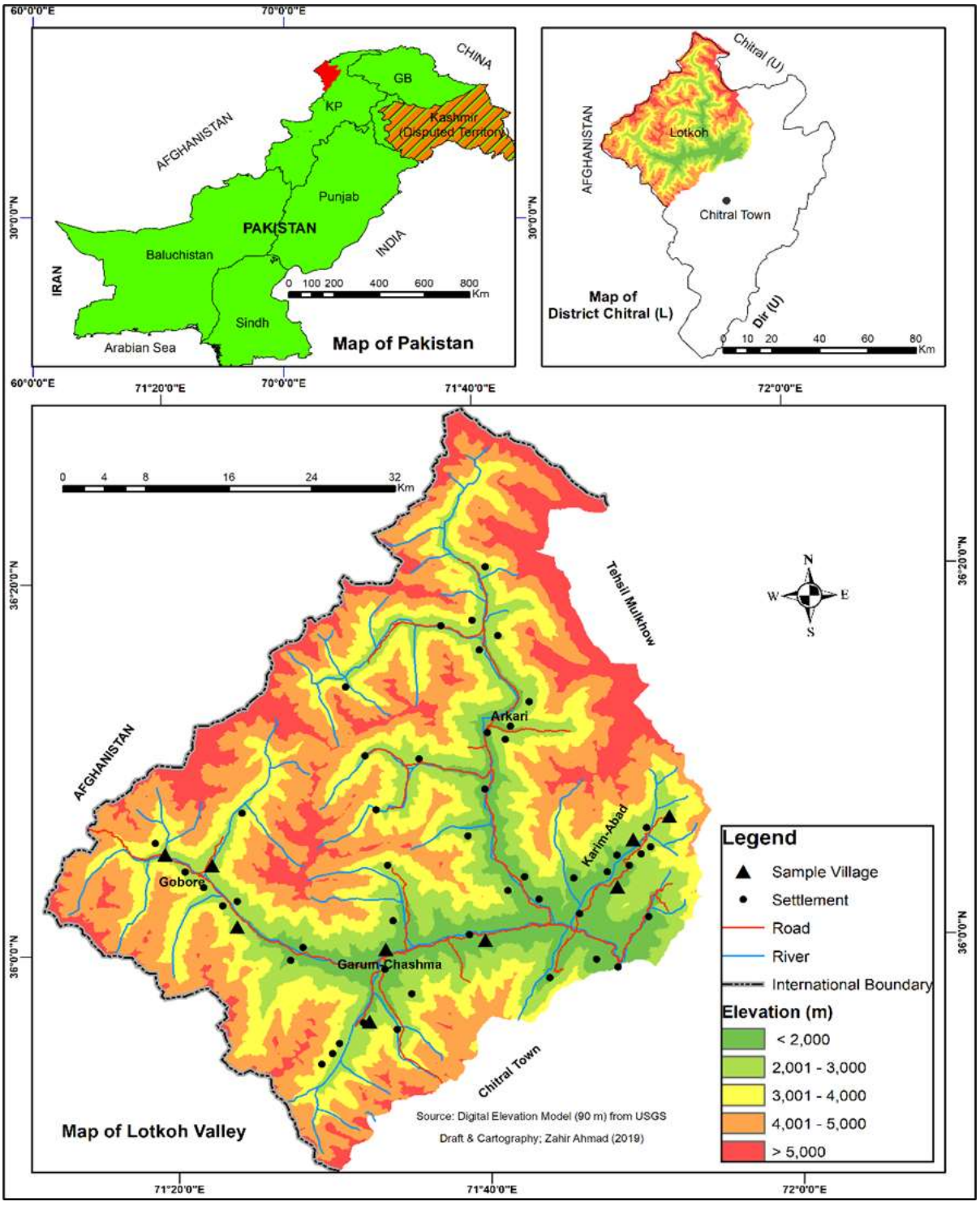
Material and Methods

Study Area

The locus of this study is Lotkuh Valley, a typical mountain region located in the Eastern Hindu Kush (EHK) mountain range. It is Pakistan's northernmost and peripheral district, adjacent to the Wakhan Corridor. It covers an area of 2412 km^2 and is divided into three sub-valleys: Karim-Abad, Garum-Chashma, and Arkari (Figure 1). The study area is highly rugged and surrounded by high ranges > 6000m of the EHK. These mountain systems are interrupted by deep, narrow valleys where farming is practiced on small alluvial fans and talus cones. Due to physiographic constraints, only a minimal land area (3%) is suitable for cultivation. The landholding size of the villagers is significantly below the subsistence level, with most households owning less than 0.5 acres (Ahmad et al., 2021). The climate of Lotkuh Valley is semi-arid. The average annual precipitation of 50 years (1967-2017) is 460 mm, and the mean annual temperature is 16 C. Moreover, the vegetation period is limited to less than 180 days (Ahmad, 2021).

It consists of three sub-units, i.e., Karim-Abad Union Council (UC), Lotkuh UC, and Shoghore UC. According to the 2017 census, the total population of Lotkuh Valley was 45,129 souls. The total number of households was 6,609, with an average household size of 6.8. The UC-wise population was 17,292 persons in Lotkuh, 15,201 persons in Karim-Abad, and 12,633 persons in Shoghore, with the number of households of 2,328, 2,369, and 1,912, respectively. Physically, Lotkuh tehsil is divided into four sub-valleys: Karim-Abad, Garum-Chashma, Gobore, and Arkari (GoP, 2018).

Figure 1: Location Map of Lotkuh Valley, District Chitral (L), North Pakistan



Data Sources

Data were explored from primary and secondary sources to achieve the study's objectives; however, this study predominantly relied on primary data. Primary data were gathered through questionnaires, observation, interviews, and focus group discussions. A multistage stratified sampling method was employed as the sampling plan for this study. Three sub-valleys (i.e., Karim-Abad, Garum-Chashma, and Gobore) were purposely selected in the first stage. In the second stage, the selected valleys were divided into three strata based on agricultural innovation and practices: a) Pea Dominated Growing Zone, b) Potato Dominated Growing Zone, and c) Transition Zone (Wheat/potato/Animal Husbandry Area). In the third stage, nine villages (three from each stratum) were selected as representative sample villages through a stratified sampling technique. In the fourth stage, household data were collected from sample villages through a proportionate random sampling technique. The following formula (1) was used to select a proportionate sample size (Barreiro & Albandoz, 2001).

$n_i = \text{n.}\left(\frac{\text{N}_\text{i}}{\text{N}}\right)$ for i = A, B, C, D, E, F, G, H, and J……..…….….. Eq. (1)

Where:

n_i = The size of sample from i^{th} stratum

n = Total sample size to be taken

N = The sum of households in sample villages

N_i = The total number of households in i^{th} stratum (here in this case, village)

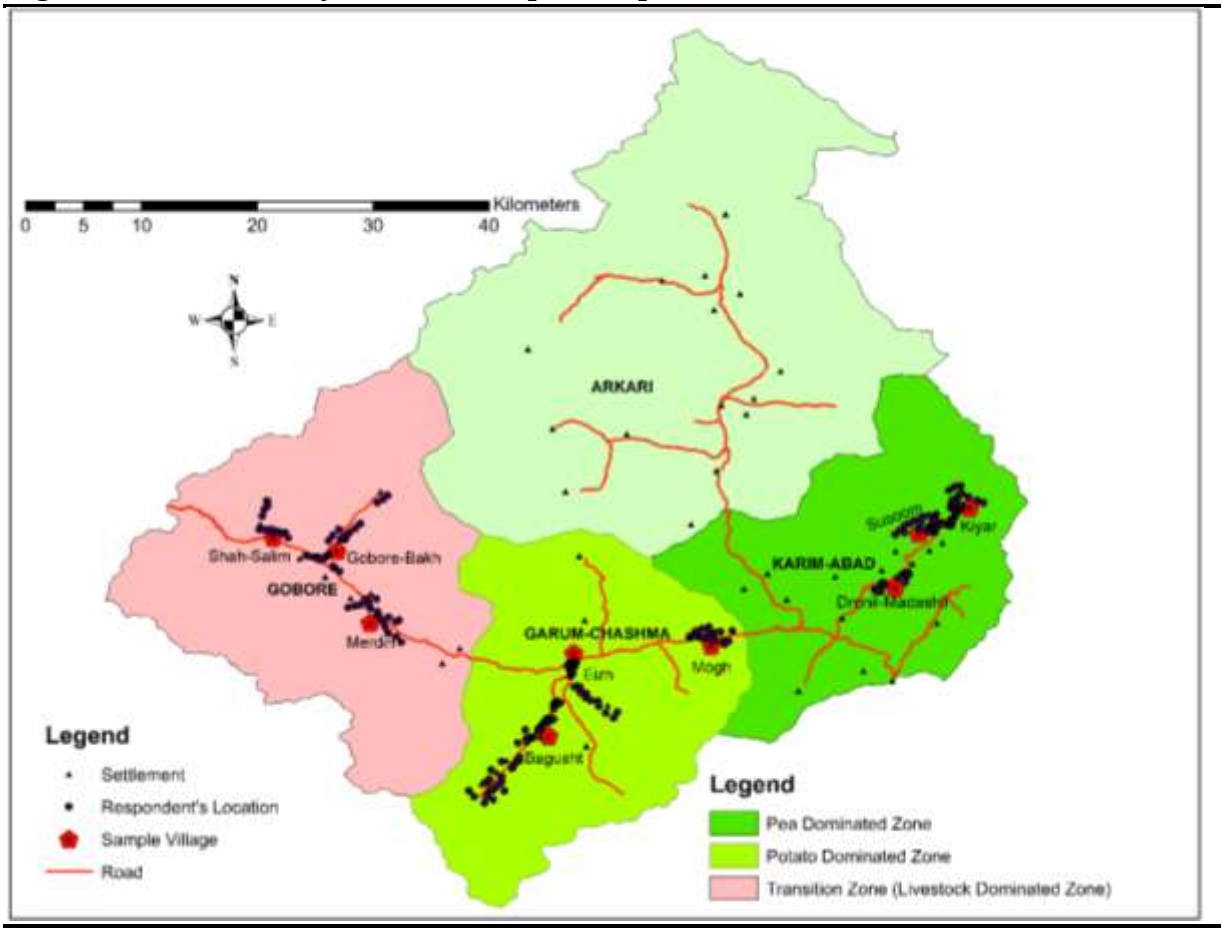
The letters A, B, C, D, E, F, G, H, and J represent the sample villages. The breakdown of the sampling frame is given in table (1). The population census 2017 was a baseline for sampling frames with sample households proportionally from strata defined by sub-villages. Considering the time and resource limitations, a proportionate stratified random sample size of 35% was surveyed from the villages comprising 356 households. During the questionnaire survey, the coordinates of respondents were recorded adequately through a Global Positioning System (GPS) device (Figure 2). FGDs were arranged in three different agricultural zones of the study area. A total of nine FGDs, one from each village, were conducted. Data were also collected from published and open sources to cross-check and validate primary information. Topographic sheets, Google Earth images, satellite images, and SRTM (Shuttle Radar Topographic Mission) data were used to create maps. In order to detect the change in accessibility, road networks of the study area have been digitized from Google Earth images from 1990 to 2019. Multispectral Landsat satellite temporal images from 1990 and 2019 with a 30-meter spatial resolution were downloaded from the USGS official website (www.earthexplorer.usgs.gov) for land use land cover analysis. Data related to population characteristics, education, migration, etc., were gathered from Census Reports of Chitral District (GoP, n.d., 1976, 1983, 1999, 2017), Gurdon's Report on Chitral 1903 (Gurdon, 1903), Military Report & Gazetteer of Chitral (General Staff India,1928) and District Census Report of Rural Settlement 1988 Chitral (GoNWFP, 1990). Necessary data related to educational institutions and student enrollments were also explored from IMU (Independent Monitoring Unit) Education Office Chitral (L). The collected data were analyzed through descriptive statistics, inferential statistical methods, and advanced cartographic techniques. The data related to the driving forces of agricultural innovation were analyzed through the Spearman rank correlation method. The multispectral temporal satellite images were analyzed using the maximum likelihood technique in ArcMap 10.5 software. Prior to classification, atmospheric and radiometric corrections were carried out. Then, the images were classified into five land use land cover classes, including agriculture, rangelands, barren land, water bodies, and snow and glaciers, using the supervised classification method. Accuracy assessments were carried out for all images of 1990 and 2019 using a confusion matrix and kappa coefficient. The overall accuracy for all the images was more than 85 percent, indicating excellent classification, high reliability, and precision in image classification results for both user and producer accuracies in the temporal Landsat satellite imagery of 1990 and 2019.

Table 1: Sampling Frame

Sub-Valleys	Locality's Name / Zone	Village's Name	Elevation in Meter (a.m.s.l.)	Total Number of Households 2017	Sample Household	Sample Size (%)
Karim-Abad	Pea Dominated Zone	i. Dronil-Madashil	2360	108	38	35
		ii. Susoom	2974	105	37	35
		iii. Kiyar	3033	125	44	35
Garum-Chashma	Potato Dominated Zone	i. Mogh	1962	95	34	35
		ii. Eizh	2275	149	53	35
		iii. Bagusht	2920	219	77	35
Gobore	Transition Zone (Livestock / Wheat / Potato Zone)	i. Merdin	2900	60	21	35
		ii. Gobore-Bakh*	3158	114	40	35
		iii. Shah- Salim	3302	30	12	36
Total				**1005**	**356**	**35**

Source: GoP, 2018 a.m.s.l. stands for above mean sea level * includes the population data of surrounding sub-villages

Figure 2: Lotkuh Valley, Location Map of Respondents, 2019



Results

Drivers of Change in Mountain Agriculture

Mountain agricultural transformation and its changing pattern are highly complex process and governed by various endogenous and exogenous catalysts in Lotkuh Valley. There are several driving forces of agricultural innovation in the study area. However, the underlying driving force includes, improved accessibility, population growth, increasing access and attainment of formal education, market integration, off-farm job opportunities, rising demand for food and developmental oriented work of NGOs. Though, these factors may be considered as a common driver of agricultural transformation and innovation in the study area. However, the intensity and nature of impact of these drivers vary from valley to valley. In order to generalize the driving forces of agricultural innovation which could be applicable for the whole Lotkuh Valley, Spearman rank correlation was employed.

Table 2: Lotkuh Valley, Driving Forces of Agricultural Innovation, 2019

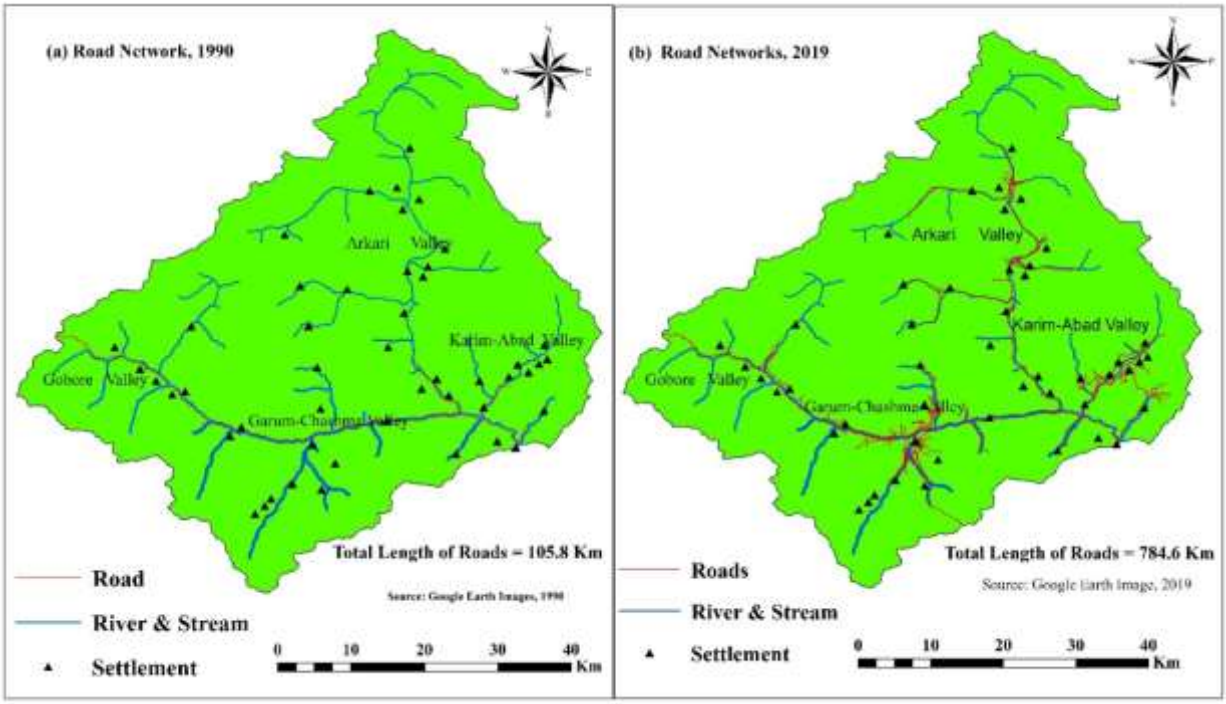
Drivers of Changes	Karim-Abad		Garum-Chashma		Gobore		Generalized RO	
	(%)	RO	(%)	RO	(%)	RO	Average	RO
Improved Accessibility	32	1	23	1	34	1	29.7	1
Population Growth	22	2	18	3	29	2	23	2
Improvement in Educational Attainment	20	3	21	2	10	4	17	3
Market Integration	9	4	8	6	15	3	10.7	4
Developmental Work of Govt and NGOs	7	5	11	5	1	7	6.3	6
Availability of Foodstuffs in the Local Market	4	7	5	7	9	5	6	7
Off-farm Job Opportunity	6	6	14	4	2	6	7.3	5
Total	100		100		100		100	

Source: Field Survey, 2019 RO stands for Ranking Order GRO stand for Generalized Ranking Order

Improved Accessibility

The improved accessibility is the leading driver of change in traditional mountain agriculture toward market-oriented cash crops economy in the study area. The impact of improved accessibility was ranked as the foremost driving force of change in the study area (Table**,** 2). This is attributed to the fact that, before 1990, most villages were not accessible to motorized traffic. In 1990, the total length of the road network in Lotkuh Valley was 105.8 kilometers (Figure 3a). Prior to 1990, link roads were not constructed, rendering only a few villages (approximately 8-10 out of 58) were accessible to motorized traffic along the main road in Lotkuh Valley. Since 1990, substantial efforts have been made to construct link roads and bridges, connecting peripheral and marginal villages to the main road. Consequently, the total road length has expanded to 784.6 kilometers by 2019 (Figure 3b). In 2019, all 58 villages in Lotkuh Valley were accessible to motorized transport, including jeeps and vehicles. Furthermore, the approximately 45-kilometer road from Chitral town to Garum-Chashma has undergone blacktopping over the last two decades.

Figure 3: Lotkuh Valley, Road Networks, 1990-2019



Population Growth

Population growth is the second major catalyst for the agriculture transformation in the study area. Since 1899, the population of Lotkuh Valley has been increasing at an alarming rate. The overall population of the sample villages has increased from 692 individuals in 1899 to 7,068 people in 2017. The population of the sample villages in the study area has increased more than tenfold over the last twelve decades. The overall population of the sample villages in Karim-Abad valley was 1,761 individuals in 1988, and it has increased by 25.7% in 2017. From 1988 to 2017, the total population of the sample villages in Garum-Chashma valley has increased by 67%. However, the population of the sample villages in Gobore valley has increased by 182%, from 610 people in 1988 to 1,720 people in 2017 (Table**,** 3). The effect of population growth on agricultural transformation varies in each sub-valley. Compared to other valleys, the highest population growth has occurred in Gobore valley. However, traditional mountain agriculture has not completely changed yet in Gobore valley due to its remote and marginal location. Over the last three decades, there has been an overall 66.4% increase in the total population of all sample villages in the study area. Therefore, it is inferred that the growing population pressure, coupled with low productivity in traditional agriculture, is the main factor in the study area. In the past, subsistence-based mixed mountain agriculture was the economic mainstay of inhabitants in Lotkuh Valley, and people lived to a high degree of self-sufficiency through well-adjusted mountain agriculture practices. However, over the last three decades, population growth has led to the fragmentation of agricultural land. Consequently, the production and yield of traditional crops have been substantially reduced, resulting in a food deficit in the study area. To cope with food insecurity, the people of the study area have substituted cereal crops for high-yielding cash crops.

Table 3: Population Growth in Sample Villages of Lotkuh Valley, 1899-2017

Valley	Sample Villages	1899	1961	1972	1981	1988	1998	2017	Percent Change 1988-2017
Karim-Abad	Dronil-Madashil	80	232	n.a.	413	594	619	735	23.7
	Susoom	80	n.a.	n.a.	497	594	686	682	14.8
	Kiyar	80	734	n.a.	437	573	721	797	39.1
Garum-Chashma	Mogh	90	n.a.	n.a.	628	505	602	676	33.8
	Eizh	95	n.a.	n.a.	445	537	678	988	84
	Bagusht	150	322	n.a.	648	834	1090	1470	76.3
Gobore	Merdin	35	101	n.a.	193	266	643	430	61.7
	Gorbore	41	299	n.a.	996	249	720	1028	313
	Shah-Salim	41	n.a.	n.a.	n.a.	95	192	262	175.8
Total Population of Sample Villages		692				4247	5951	7068	66.4
Total Population of Lotkuh Valley		5,836	13,017	19,132	23,622	29,542	37,383	45,126	52.8
Source: Military Report & Gazetteer on Chitral, 1928, GoP, 1981, 1998, 2018 & GoNWFP, 1990									

Improvement in Educational Attainment

Improvement in educational attainment is a major driving force for transforming traditional mountain agriculture in Lotkuh Valley. Children traditionally played a significant role in carrying out agricultural tasks, particularly in animal tending (Ahmad, et al., 2021). However, with the increasing emphasis on education and rising school enrollment, the availability of children for agricultural work has diminished. Consequently, there is a shortage of labor force for tending to livestock. Furthermore, educated individuals are becoming less inclined to engage in animal-keeping activities, opting instead for non-agricultural pursuits. Over the last three decades, the education sector in Lotkuh Valley has undergone significant changes. During this period, numerous new schools have been established. For example, in 1988, there were a total of 42 educational institutions in Lotkuh Valley, a number that increased to 94 by 2020. Moreover, the total number of registered students was 2,724 in 1988 which increased by 109% in 2020 (Table, 4).

Table 4: Lotkuh Valley, Number of Govt. Schools and Students Enrolment, 1988-2020

Institutions	Category	No. of Schools		Enrolment in Schools		% Change in
		1988	2020	1988	2020	Total Enrolment
Govt. Primary School	Boys	30	47	1670	2773	66.0
	Girls	8	29	508	775	52.6
Govt. Middle School	Boys	2	5	415	874	110.6
	Girls	0	1	70	367	424.3
Govt. High School	Boys	2	7	87	600	589.7
	Girls	0	3	4	193	4725.0
Govt. Higher Secondary School	Boys	0	1	0	88	x
	Girls	0	1	0	94	x
Total		42	94	2754	5764	109.3
Source: GoNWFP, 1990		Independent Monitoring Unit (IMU), Elementary & Secondary Education Office Chitral (Lower), 2020				

Market Integration

Market integration is another critical factor driving changes in the mountain agricultural system in Lotkuh. The effect of market integration varies greatly from valley to valley, with Karim-Abad, Gram-Chashma, and Gobore ranking 4th, 5th, and 6th, respectively. Due to market integration, agricultural changes have occurred in the Gobore and Karim-Abad valleys. Before 1990, local products from Lotkuh Valley were kept from the national market. Currently, agricultural products from the study area are sold in the national market. Additionally, agricultural inputs such as potato/pea seeds, fertilizers, pesticides/insecticides, etc., are available in the local market of the study area.

Off-farm Job Opportunity

Off-farm job opportunities and cash income play a crucial role as agents of change in traditional mountain agriculture. In the study area, off-farm activities are gaining prominence due to the reduced capacity of mountain agriculture to absorb the growing population. Moreover, the non-farm sector absorbs the growing labor force. Three decades ago, Lotkuh Valley experienced almost negligible off-farm job opportunities and a lack of cash income sources. Trade primarily relied on the exchange of products. In the current scenario, diverse means of generating off-farm incomes are available in Lotkuh, including employment opportunities in education, the army, health, and tourism.

Furthermore, seasonal migration to lowlands and international migration also significantly contribute to off-farm income. Compared to other valleys, Garum-Chashma exhibits a higher potential for off-farm activities. It is a hub for various government and private institutions, including educational institutions, police stations, Chitral Scout garrisons, hotels, etc. The impact of off-farm job opportunities in Garum-Chashma is ranked fourth. Nevertheless, off-farm job opportunities remain comparatively limited in both Karim-Abad and Gobore valleys, placing them at a lower sixth ranking order in both areas (Figure 4). Furthermore, the generalized ranking order of driving forces behind agricultural innovation reveals that the role of off-farm activities as agents of agricultural transformation is positioned at 5th in the overall ranking order.

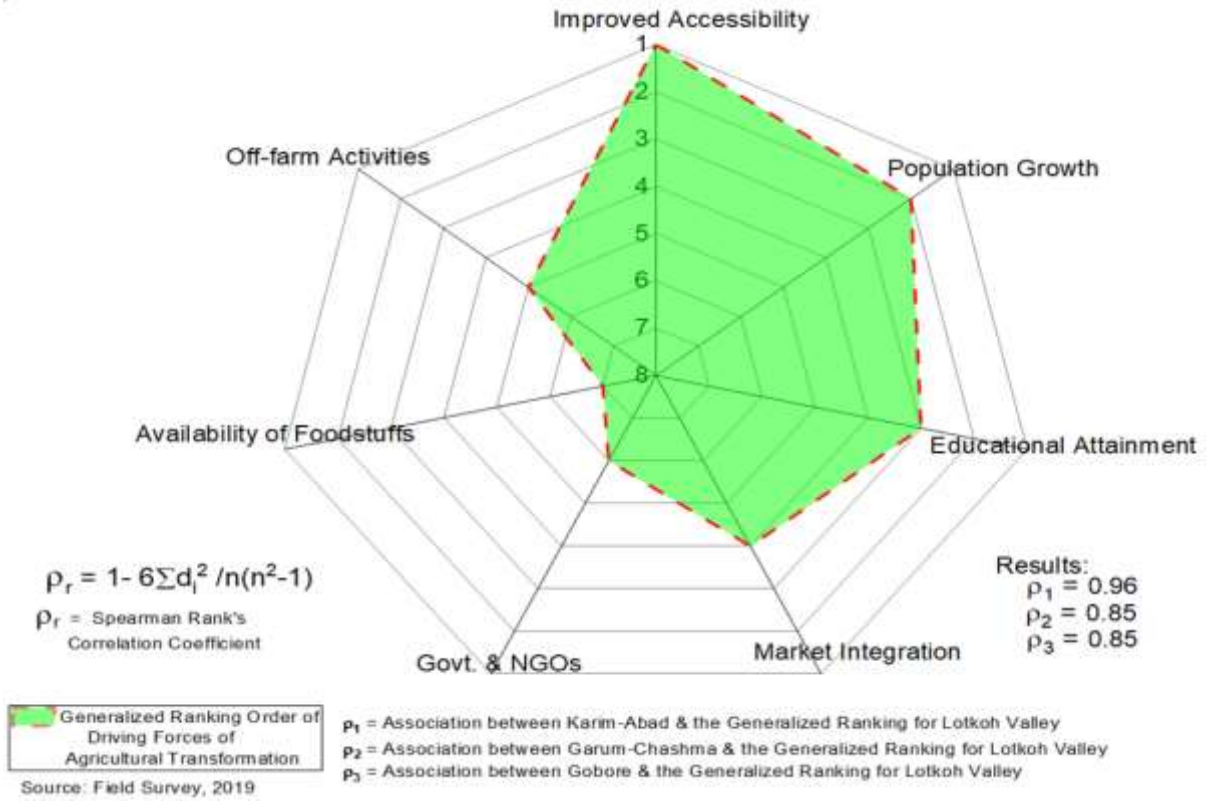
Developmental Work of Government and NGOs

Since 1990, governmental and non-governmental organizations (NGOs) have played a pivotal role in the development of Lotkuh Valley. Governmental projects focused mainly on improving transportation facilities, constructing health facilities and schools, and providing subsidized grain supplies in Lotkuh Valley. NGOs have played a significant role and have been actively involved in agricultural development, introducing new crops, fruits, and vegetables, and supporting people in the construction of greenhouses, distribution of improved crop seeds, establishing fruit nurseries, and engaging in the drying and preservation of fruits, among other initiatives. Furthermore, NGOs were dominant in constructing roads, health facilities, and educational institutions. However, NGOs' role in the study area's development varies from valley to valley. NGOs are active in some areas, such as Garum-Chashma and Karim-Abad valleys, while they are less active in Gobore Valley. Therefore, the role of Non-Governmental Organizations (NGOs) is ranked as the fifth major driving factor in both Karim-Abad and Garum-Chashma (Figure 4). However, the developmental work of NGOs is almost negligible in Gobore Valley. This valley was neglected by NGOs and ignored by the government due to its marginality and inaccessibility.

Availability of Foodstuffs in the Local Market

The underlying cause of the agricultural transformation is the availability of foodstuffs and subsidized grain in the study area. Three decades ago, grains, flour, and other products were not readily available in the local market. These products can be accessed in utility stores and the local market for cash. Consequently, traditional cropping patterns and livelihood strategies have undergone substantial modification. Subsidized grain and flour availability in the local market is the primary catalyst for agricultural innovation. In addition to these factors, some other minor drivers of agricultural change include remittances from the Middle East, abolishing the feudal system, and changing the political system.

Figure 4: Lotkuh Valley, A Generalized Model of Driving Forces of Agricultural Innovation



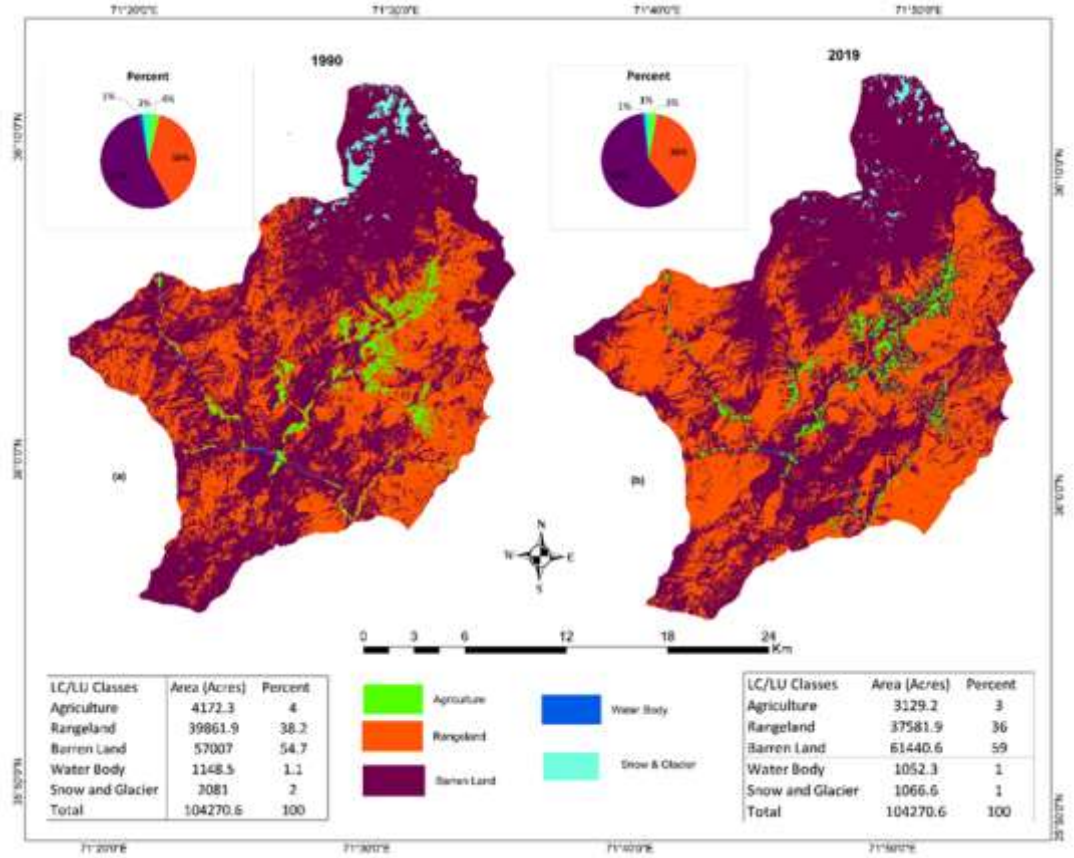
Changes in Mountain Agriculture

Like the traditional livelihood of the northern mountains of Pakistan, the basis of the centuries-old subsistence economy in Lotkuh Valley was agropastoralism, which played a pivotal role in subsistence survival and livelihood security. Several vivid changes have occurred in different components of traditional livelihood strategies. These changes include land use/cover alterations, agricultural landholding, cropping patterns, agricultural input and output, farming methods, livestock size, arboriculture, etc.

Land Use and Land Cover Change

The land use/cover (LU/LC) of Lotkuh Valley has undergone substantial changes over the last three decades. Lotkuh Valley's land use/cover has been categorized into five classes: agricultural land, barren land, rangeland, water bodies, and glaciers. Over the past three decades, notable changes have occurred in all five-land use/cover categories. In Karim-Abad, agricultural land decreased from 4,172 acres in 1990 to 3,129 acres in 2019. Rangeland has also reduced from 39,861 acres in 1990 to 37,581 acres in 2019. Conversely, barren land has increased from 57,007 acres in 1990 to 61,440 acres in 2019 (Figure 5). The rise in barren land can be attributed to rangeland degradation ad desertification. Similarly, in the Garum-Chashma Valley, agricultural land has decreased from 5,747 acres to 4,638 acres between 1990 and 2019. Rangeland has experienced a decrease from 56,530 acres in 1990 to 48,298 acres in 2019. Parallel to the Karim-Abad Valley, barren land has increased from 50,270 acres in 1990 to 29,695 acres in 2019 (Figure 6). In Gobore Valley, over the last three decades, agricultural land has decreased from 5,263 acres to 4,158 acres, attributed to the conversion of agricultural land into built-up areas due to population growth, etc. Rangeland has decreased from 52,558 acres in 1990 to 49,731 acres in 2019, with overgrazing and desertification contributing to this decline. Consequently, barren land has increased from 74,997 acres in 1990 to 81,377 acres in 2019 (Figure 7).

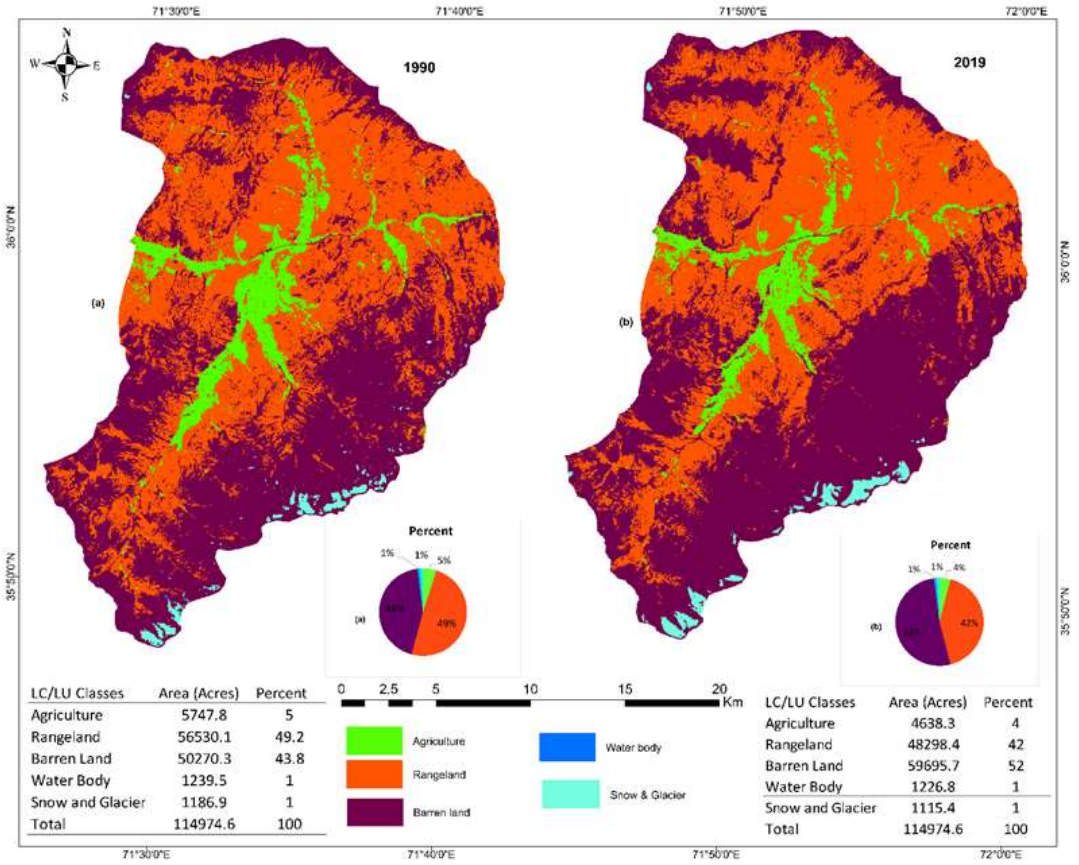
Figure 5 (a - b): Karim-Abad Valley, Land Cover / Use Change Map, 1990-2019.



LC/LU Classes	Area (Acres)	Percent
Agriculture	4172.3	4
Rangeland	39861.9	38.2
Barren Land	57007	54.7
Water Body	1148.5	1.1
Snow and Glacier	2081	2
Total	104270.6	100

LC/LU Classes	Area (Acres)	Percent
Agriculture	3129.2	3
Rangeland	37581.9	36
Barren Land	61440.6	59
Water Body	1052.3	1
Snow and Glacier	1066.6	1
Total	104270.6	100

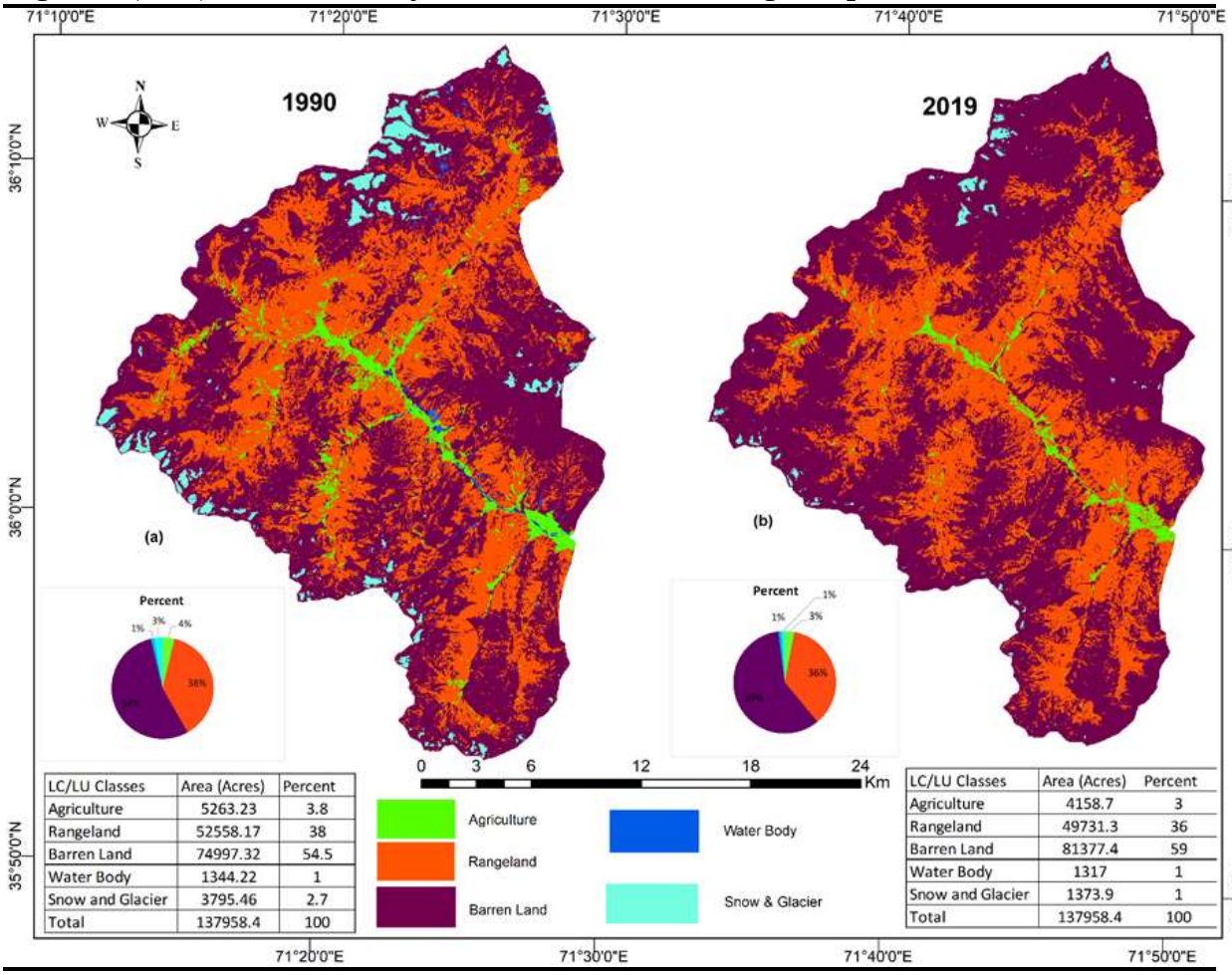
Figure 6 (a - b): Garum-Chashma Valley, Land Cover / Use Change, 1990-2019



LC/LU Classes	Area (Acres)	Percent
Agriculture	5747.8	5
Rangeland	56530.1	49.2
Barren Land	50270.3	43.8
Water Body	1239.5	1
Snow and Glacier	1186.9	1
Total	114974.6	100

LC/LU Classes	Area (Acres)	Percent
Agriculture	4638.3	4
Rangeland	48298.4	42
Barren Land	59695.7	52
Water Body	1226.8	1
Snow and Glacier	1115.4	1
Total	114974.6	100

Figure 7 (a - b): Gobore Valley, Land Cover / Use Change Map, 1990-2019



Changes in Cropping Pattern

For the past three decades, Lotkuh Valley has undergone drastic changes in its cropping pattern. Historically, farmers considered four main factors while selecting crops: food and fodder self-sufficiency, crop suitability, and soil fertility. Prior to 1990, more than fifteen different types of crops were cultivated. However, the results from Table 5 reveal that the old cropping pattern has changed, and approximately seven indigenous crops, including poppy, hemp, millet, and lentils, have completely disappeared. In the past, poppy and hemp were major cash crops in Chitral (Kreutzmann, 1998). However, these crops are no longer cultivated in the study area due to a state-imposed ban. The cultivation of both summer and winter wheat has also decreased. In 1990, barley was the major crop in the study area, but it is currently considered an endangered crop. Recently, significant changes and innovations have occurred in the cultivation of potatoes, peas, tomatoes, and beans. These cash crops are now cultivated on a large scale compared to 1990.

Table 5: Lotkuh Valley, Changes and Innovation in Type of Agricultural Crops

English/Local Name	Botanical Name	Before 1990	2019
Winter Wheat	*Triticum durum*		
Spring Wheat	*Triticum durum*		
Green Bean *(Kanis)*	*Vigna radiata*		
Paddy *(Shali)*	*Oryza sativa*		
Potato	*Solanum tuberosum*		
Green Pea	*Pisum sativum*		
Tomato	*Solanum lycopersicum*		
Black Gram	*Vinga mongo*		
Barley	*Hordeum vulgare*		
Maize	*Zea mays*		
Black Pea	*Vigna unguiculata*		X
Proso Millet	*Panicum miliaceum*		X
Chickpeas *(Nakhoay)*	*Cicer arietinum*		X
Lentil *(Sherjo)*	*Lens esculenta*		X
Foxtail Millet *(Grass)*	*Setaria italica*		X
Opium Poppy	Papaver somniferum		X
Hemp	*Cannabis sativa*		X
Source: Field Survey, 2019			
Subsistence Crop		Crop Disappeared	X
Cash Crop		Endangered Crops	

Change in Livestock Size and Composition

Livestock is dynamic, and its size and composition change over time and space in Lotkuh Valley. For the last three decades, animal husbandry has undergone several visible transformations and changes. These include changes in livestock population, composition, commercialization of animal husbandry, and alternation in livestock grazing mechanism and arrangement. Diversity is the salient feature of animal husbandry in the study area. Three decades ago, a household herd was generally composed of seven species: goats, sheep, cow, bullock, donkey, horse, and yak. The diverse herd composition is not only a primary strategy for mediating risk and seasonal shocks (Nüsser & Clemens, 1996; Ning, 1997; MacDonald, 1998). Since 1990, livestock keeping has substantially declined. The swift decline of the livestock population is remarkable for goats. During 1990-2019, goats decreased by 91% in Karim-Abad, 85% in Garum-Chashma, and 42% in Gobore. This abrupt decrease can be attributed to the imposition of a local ban on grazing goats in alpine pastures. This ban has been imposed by the local people in order to control flash floods during the summer season. The number of sheep decreased by 79% in Karim-Abad, 82% in Garum-Chashma and 57% in Gobore. Horses and donkeys have almost disappeared in Karim-Abad and Garum-Chashma due to improved accessibility and access to motorized transport. The location of Gobore, particularly Shah-Salim, is highly suitable for keeping yak. Yak is almost an un-attended animal, but surprisingly, a few households kept yak in the past. Moreover, the population of yak has also been reduced from 1990 to 2019 (Table 6).

Table 6: Spatio-temporal Dynamic in Livestock Population and Composition in Lotkuh Valley, 2019

Type of Livestock	Karim Abad Valley				Garum-Chashma Valley				Gobore Valley			
	1990		2019		1990		2019		1990		2019	
	Number	AV/HH	Number	AV/HH	Number	AV/HH	Number	AV/HH	Number	AV/HH	Number	AV/HH
Goat	1706	14.3	144	1.2	2390	14.6	348	2.1	1182	16.2	685	9.4
Sheep	2122	17.8	435	3.7	2838	17.3	514	3.1	1417	19.4	613	8.4
Cow	271	2.4	166	1.4	385	2.3	285	1.7	435	5.9	281	3.8
Bullock	138	1.2	17	0.1	136	0.8	44	0.3	116	1.6	95	1.3
Donkey	105	0.8	0	0.0	103	0.6	0	0.0	75	1.02	12	0.2
Horse	15	0.1	0	0.0	23	0.1	0	0.0	49	0.7	21	0.3
Yak	0	0	0	0.0	0	0	0	0.0	15	0.2	7	0.1
Source: Field Survey, 2019 AV/HH stands for average per household												

Change in Grazing Arrangement

Generally, children play a significant role in animal tending; however, this is changing because the increasing school enrollment and the importance of education have reduced the availability of children for work. Consequently, there is a need for more labor for tending livestock. To cope with this situation, the villagers hire professional shepherds (*gujur*) to herd the village community's flock of goats and sheep. Thus, the traditional grazing arrangements are replaced with paid grazing methods. This new arrangement was recently introduced in Karim-Abad and Garum-Chashma Valley in response to labor shortages. However, this newly introduced grazing arrangement negatively impacts rangeland resources. *Gujur*, who are non-local and have no stake in local resources, exploit rangeland resources ruthlessly. Moreover, they have over 100 sheep and goats and do not practice rotational grazing. Generally, overgrazing and overexploitation of pastoral resources are attributed to *gujur* in Chitral (Parkes, 1987; Mulk, 1991, 1992). The rangeland of Lotkuh Valley decreased from 274,177 acres in 1990 to 244129 acres in 2019. However, the traditional grazing method is still practiced in Gobore Valley (Ahmad, 2021).

Change in Arboriculture

Similar to other elements of mountain agriculture, transformation has occurred substantially in arboriculture. Previously, fruit trees were planted at a minimal scale for subsistence. Currently, different varieties of fruit trees are planted for commercial purposes in the Garum-Chashma and Karim-Abad valleys. Amongst commercial fruits, apples, walnuts, pears, dried mulberries, and dried apricots are a subsidiary source of cash income for the inhabitants of the Garum-Chashma and Karim-Abad valleys. However, fruit trees are not planted in Gobore Valley due to the high altitude.

Change in Aquafarming and Apiculture

The whole Lotkuh Valley has an ideal location for promoting and developing fish farming. The study area has sufficient water, which is highly suitable for the culture of the Salmonid species, i.e., Rainbow trout and Brown trout. Historically, the first fish pound was constructed in Chitral at Mastuj during the British period in 1927. Later on, in 1930, brown trout were stocked in the River Lotkuh (Ahmad, 2021). However, aquaculture in the private sector has recently been introduced in the study area. Field observation shows that two households in the village of Mogh were engaged in aquaculture.

Though apiculture is an age-old practice, commercial apiculture has recently been introduced and is emerging as an essential additional source of cash income in the study area. However, in the past, wild honey was harvested on a minimal scale for household consumption and medicinal purposes. According to FGDs, apiculture has been recently introduced in a modern way in the study area. Recently, a few households, such as 4.8% in Garum-Chashma and 3.3% in Karim-Abad Valleys, have adopted as an additional source of cash income. They are producing honey for commercial purposes. The small-scale commercial apiculture contributes substantially to the food and livelihood security of the inhabitants of the study area (AKRSP-Chitral, 2011). However, commercial apiculture has yet to develop been developed in Gobore Valley.

Discussion and Conclusion

Since 1990, vivid and palpable changes have occurred in traditional mountain agriculture, and the manifestation of these changes is multifarious and ostensibly visible in the study area. However, these changes are not restricted to Lotkuh Valley but are global phenomena experienced across mountain regions worldwide (Bernués et al., 2016; Dach et al., 2014; Knapp, 2016; Kreutzmann, 2020; Stephen, 2015). For centuries, traditional mountain agriculture served as a fundamental underpinning and the avenues of subsistence survival and

lynchpin of the economy of the inhabitants of the EHK. The inhabitants of EHK were self-sufficient under the mean of a well-adjusted mountain agricultural system. However, several vivid changes and palpable transformations have occurred in mountain agriculture. These changes include land use/cover changes, dynamics in agricultural land holding, cropping patterns, agricultural inputs and outputs, farming methods, changes in livestock size, arboriculture, etc. However, drastic changes have been witnessed in cropping patterns.

In the past, farmers in the study area cultivated more than fifteen varieties of crops. Most of these crops have disappeared, and new cash crops such as tomato, potato, and pea have been introduced. In the past, farmers in the study area were generally focused on four main issues: food self-sufficiency, fodder self-sufficiency, crop suitability/frost resistance, and soil fertility, while selecting crop types. However, at present, the primary focus of farmers is high-value, market-oriented cash crops. Nevertheless, these changes are unique throughout the study area. In the lower part of the study area, mountain agriculture and cottage industry have predominantly been replaced by cash crop cultivation, resulting in apparent consequences.

Moreover, the inhabitants of this area have more access to other sources of off-farm income, such as military and civil services and business opportunities. In the upper part of the study area, located close to the famous Wakhan Corridor, traditional mountain agriculture is still practiced with minor changes due to its peripheral location and limited off-farm income opportunities. The age-old traditional system of economic organization heavily based on locally available resources is still in vogue.

The manifestation of these changes is multifarious and ostensibly visible throughout the study area. However, these transformations and changing patterns are highly complex and governed by diverse exogenesis and endo-genesis driving forces. There are seven underlying drivers behind the mountain agricultural transformation. These include improved accessibility, population growth, improvement in formal educational attainment, market integration, off-farm job opportunities, developmental work of NGOs and Government, and availability of exogenous foodstuffs (Hussain et al., 2005; Rana et al., 2021; Spies, 2018). The improved accessibility is the primary driver of the traditional mountain agricultural system towards a market-oriented cash crops economy. The road network in Lotkuh Valley has increased from 105.8 km in 1990 to 784.6 km in 2019. Population growth is the second major catalyst influencing the mountain agricultural systems. The exponential increase in population has triggered shifts in land use land cover, fragmentation of agricultural land, and alterations in traditional cropping patterns. The intensification of agriculture and the transition from subsistence-based mountain agriculture to high-yielding cash crops signify adaptive responses to the challenges posed by population pressure and dwindling productivity. Education attainment is considered the third major driving force of agricultural innovation. The substantial improvements in education infrastructure, increase in enrollment in education, market integration, off-farm job opportunities, and the developmental work of government and NGOs collectively contribute to the diversification of livelihoods and income sources. The innovation in mountain agriculture entailed a variety of opportunities and increased agricultural production and yield manifold. The manifestation of agricultural innovation is ostensibly visible in economic growth, food security, livelihood sustainability, and poverty eradication. The findings of this research underscore the necessity for adaptive strategies that harmonize economic development with environmental sustainability, providing essential insights for policy formulation in mountainous regions.

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