

“UNDERUTILIZATION OF HIGH MOUNTAIN RESOURCES IN GILGIT-BALTISTAN, PAKISTAN: A MIXED-METHOD REVIEW-BASED ANALYTICAL STUDY OF CLIMATIC, SOCIOECONOMIC, ENVIRONMENTAL CHALLENGES AND DEVELOPMENT OPPORTUNITIES”

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ABSTRACT

The study is based on a mixed-method review-based analytical approach integrating secondary datasets, comparative regional assessment, and evidence-based thematic analysis covering the period 1990–2023, to examine climatic, socioeconomic, environmental, and governance-related determinants of resource underutilization and food security in Gilgit-Baltistan, Pakistan. Gilgit-Baltistan (GB), located in northern Pakistan, is the only region that hosts all of the country's mountain peaks rising above 8,000 meters, including some of the world's highest summits. Despite its immense natural wealth and significant potential for economic growth, tourism, agriculture, and environmental resources, the region remains largely underutilized. This underutilization is primarily attributed to inadequate infrastructure, poor road connectivity, limited access to healthcare and education, restricted market access, insufficient investment, and policy instability. These constraints have hindered business operations, reduced regional integration, and limited the sustainable use of natural and agro-based resources. This study examines the major factors influencing food security and resource utilization in the mountainous region of Gilgit-Baltistan, with particular emphasis on climatic challenges, socioeconomic conditions, environmental impacts, and development opportunities. The research also compares food security conditions between mountainous and plain regions of Pakistan and extends the analysis to the Hindu Kush Himalayan (HKH) region in comparison with neighboring countries. Using a mixed-method and evidence-based descriptive research approach, the study highlights the interconnected effects of climate vulnerability, governance limitations, and economic constraints on livelihoods and food availability. The findings suggest that coordinated efforts by government institutions, non-governmental organizations, researchers, and local communities are essential to improve food security and promote sustainable development in GB. The study proposes policy recommendations focused on infrastructure development, market integration, research-driven resource exploration, and better utilization of agro-ecological resources to strengthen regional and national economic growth.

Keywords:

Socioeconomics, Agricultural economics, Food security, Mountain resources.

INTRODUCTION

Underutilization refers to a condition in which available resources are not utilized to their full productive, economic, and ecological potential. In the context of Pakistan's mountainous regions, underutilization can be defined as the failure to optimally harness the natural, ecological, and economic resources present in high-altitude areas for sustainable development and livelihood improvement. These mountainous regions are endowed with diverse resources, including minerals, freshwater, forests, fauna, and flora, all of which play a critical role in supporting local livelihoods and contributing to national food security and economic development. However, inefficient resource utilization can lead to lost economic opportunities, environmental degradation, and increased social vulnerability, whereas sustainable management of these resources can enhance regional development, biodiversity conservation, and climate change adaptation outcomes.

Gilgit-Baltistan (GB) is a strategically significant mountainous region in northern Pakistan, distinguished by the presence of all five of Pakistan's peaks exceeding 8,000 meters, including K2, Nanga Parbat, Broad Peak, Gasherbrum I, and Gasherbrum II. Owing to its unique topography, ecological richness, glaciers, mineral reserves, water resources, and agro-based potential, the region holds immense importance for national economic growth, food security, climate resilience, and sustainable development.

Despite this exceptional resource base, GB remains substantially underutilized. Over the last three decades, limited infrastructure, difficult terrain, poor market access, inadequate policy support, and climate-induced vulnerabilities have restricted the region's development potential. The consequences of this underutilization extend beyond the local population and significantly influence national food systems, livelihoods, environmental sustainability, and economic growth.

Food insecurity remains one of the most pressing challenges in GB. The mountainous terrain, fragmented agricultural landholdings, harsh climatic conditions, and limited access to storage, transportation, and markets collectively reduce agricultural productivity and increase livelihood vulnerability. These challenges are further exacerbated by climate change, glacier retreat, floods, and landslides.

While previous studies have examined individual dimensions such as agriculture, climate vulnerability, or tourism development, limited research has comprehensively integrated the relationships among resource underutilization, food insecurity, socioeconomic constraints, and environmental pressures in GB. Therefore, this study addresses this research gap by presenting a multidisciplinary analysis of the climatic, socioeconomic, and governance-related factors influencing sustainable resource utilization in the region.

The scope of this study is limited to Pakistan's high mountain systems, particularly those with peaks above 8,000 meters. Pakistan is home to some of the world's highest mountain ranges, including the Karakoram, Himalaya, and Hindu Kush. Globally, only fourteen peaks exceed 8,000 meters in elevation, and a significant proportion of these are located in Pakistan, with five major peaks above 8,000 meters, including K2 (8,611 m), Nanga Parbat (8,126 m), Broad Peak (8,051 m), Gasherbrum I (8,035 m), and Gasherbrum II (8,035 m) (Summit-Post Concordia Expeditions Pakistan). These peaks are primarily concentrated in the Karakoram and Himalayan ranges, making Pakistan one of the most significant mountainous regions in the world in terms of high-altitude geography. Notably, literature indicates that all of Pakistan's 8,000-meter peaks are located within Gilgit-Baltistan, a region situated at approximately 35°21'N 75°54'E, making it a critical focus for studying mountain resource utilization and associated development challenges.

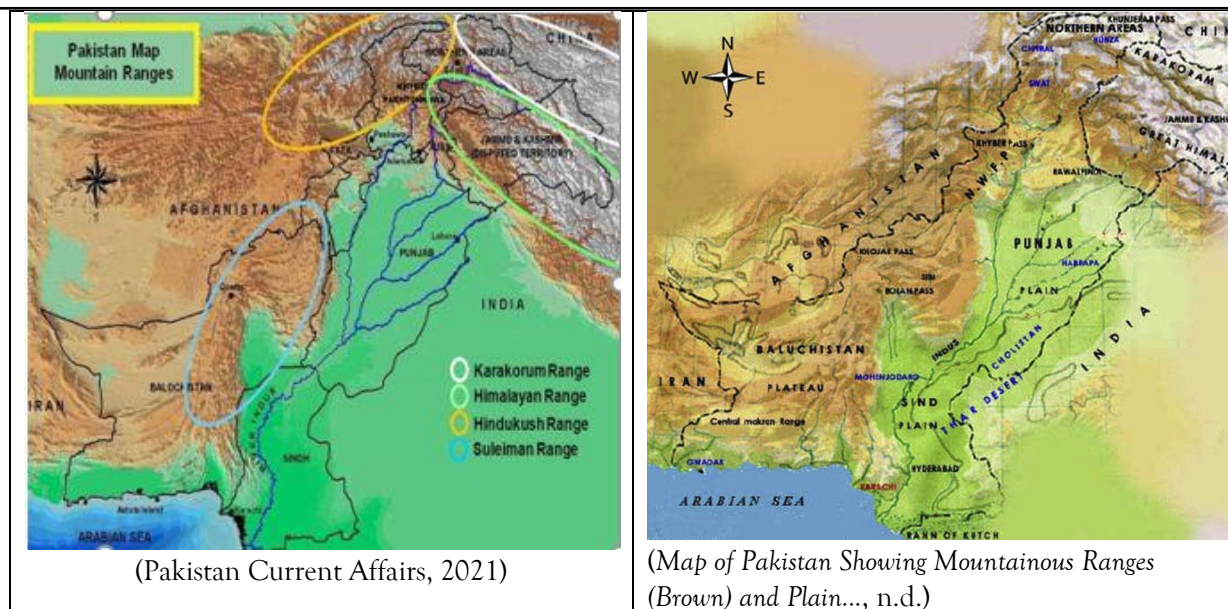


Figure 1: Map showing Mountains ranges and mountainous of Pakistan brown and plain

Accordingly, Gilgit-Baltistan has been selected as the primary study area to examine the determinants of mountain resource underutilization and its impacts on food security, socioeconomic development, and environmental sustainability in Pakistan. The study further explores the ecological and economic potential of different districts within Gilgit-Baltistan to better understand regional disparities and development opportunities. This analysis is particularly important in the context of the Hindu Kush Himalayan (HKH) region, where rapid socioeconomic transformation, climate change, and fragile topography have intensified food insecurity and livelihood vulnerability. Despite being rich in agro-based and natural resources,

mountain regions of Pakistan experience disproportionately high levels of food insecurity compared to lowland areas, as mountain niche products remain largely underexploited. Consequently, food insecurity and nutritional deficiencies are more prevalent among mountain populations, highlighting the urgent need for sustainable resource management and integrated development strategies (Rasul & Hussain, 2015). Although previous studies have explored food security and climate vulnerability in GB, limited research has comprehensively examined the relationship between mountain resource underutilization, socioeconomic constraints, and long-term development opportunities over the last three decades.

Literature Review

Table-1: for Literature Review

Sr. No:	Gilgit Baltistan	
1	Resources	Eco resources are available in the Baltistan region because the Himalayas, Karakoram and Hindukush are three of the most well-known mountain ranges in the globe and they all meet in Baltistan.
2	Areas and Crops	Karakoram Highway and Skardu Road, Skardu is 793 kilometers from Islamabad. Shigar Valley, which is only 23 km by jeep route from Skardu, is the entrance to the great Karakoram mountain peaks, Gasherbrum and K-2. Terraces of wheat, maize, and barley cover the gentle, irrigated hills of the Shigar Valley.

3	Gardens	Baltistan is known for its gardens of apricots, mulberries, peaches, plums, pears, apples, and nuts. The hamlet are the old Fort and Palace of the ex-Raja. A 241 km long Skardu Road links Skardu with Gilgit.
4	Weather and Season	From April to October is prime travel time. The highest temperature is 27 C° and lowest is 8 C° in October. Baltistan's five valleys (Shigar, Skardu, Khaplu, Rondu, and Kharmang) are renowned for their succulent peaches, apricots, apples, and pears.
5	Environment	The Northern Areas experience an alpine environment. While the late summers are very nice, winters frequently have a cold climate. The beauty of the colors during each of the four seasons is unique.
6	Nanga Parbat	Whereas, Nanga Parbat is Pakistan's second-highest peak after K2, ranking ninth among all mountains in the globe. It is situated in Pakistan's Gilgit province's Diamir district. The Himalaya is anchored to the west by Nanga Parbat. The powerful Indus River divides it from the Karakoram Mountains. It rises straight from the Indus Valley(Skardu, n.d.-b). To lead a healthy and productive life and for socioeconomic growth, food and nutrition security is crucial. For millennia, the system of food production and consumption has influenced human civilization and the environment.
7	Sustainable Development Goal	Thus, ensuring the availability of food and nutrition is essential for all societies and is given top precedence in national, international, and environmental development agendas, it is essential for reaching Sustainable Development Goal (SDG) 2 as well as SDGs 1 (no poverty), 3 (good health and wellbeing), 6 (clean water and sanitation), 12 (responsible consumption and production), and 13 (climate action) (FAO, 2017).

Statement of the Problem

Gilgit-Baltistan (GB), despite its immense ecological, strategic, and economic significance, has continued to face persistent developmental challenges that have constrained its growth potential over the years. The region is characterized by chronic underdevelopment, widespread poverty, inadequate infrastructure, and limited market integration, all of which have hindered the effective utilization of its abundant natural and economic resources. Although several transformative initiatives, such as the China-Pakistan Economic Corridor (CPEC), tourism promotion, agricultural modernization, and livestock development programs, have been proposed and partially implemented in recent years, these sectors continue to suffer from low productivity, poor value addition, weak quality standards, and insufficient access to national and international markets. As a result, the region's substantial potential in agriculture, tourism,

hydropower, mineral resources, and mountain-based livelihoods remains largely underexploited. The problem becomes more critical when viewed in the broader context of mountain communities worldwide. Approximately one-tenth of the global population resides in mountainous regions, which collectively cover nearly one-fifth of the Earth's land surface. While these areas are often recognized for their scenic beauty and ecological importance, the socioeconomic realities of mountain inhabitants are frequently overlooked. A significant proportion of these populations experience poverty, marginalization, and food insecurity. In rural mountain areas, nearly one in every two people lacks adequate access to food, compared with the global average of one in eight. It is estimated that nearly 300 million mountain dwellers live in poverty, with almost half experiencing chronic hunger and nutritional insecurity. Within this context, the underutilization of mountainous regions such as Gilgit-Baltistan can be defined as the failure to

optimally harness their natural resources, economic opportunities, and human potential for sustainable development, food security, and improved livelihoods. This persistent gap between resource availability and actual utilization forms the central problem addressed by this study.

Over the years, Gilgit Baltistan has faced several economic challenges, including underdevelopment, poverty, and lack of infrastructure, which have hindered its potential for growth and prosperity. However, there have been several economic transformative initiatives that have been proposed or implemented in recent years to address these challenges, like CEPEC, tourism development, agricultural and livestock development but still these sectors and others are often characterized by low productivity, poor quality, and limited access to markets.

Research Gap and Justification

Although a growing body of literature has examined various dimensions of development in Gilgit-Baltistan, including tourism potential, agricultural production, climate vulnerability, and infrastructure development, there remains a significant gap in integrated research that comprehensively links the underutilization of mountain resources with food security, socioeconomic constraints, environmental degradation, and governance challenges. Most previous studies have focused on individual sectors in isolation, such as climate change impacts, agricultural productivity, or regional development initiatives, without providing a holistic framework that explains how these factors collectively influence sustainable mountain development.

Furthermore, limited research has critically assessed the long-term implications of resource underutilization in Gilgit-Baltistan over the last three decades, particularly in relation to food insecurity and livelihood resilience in comparison with other mountainous regions of the Hindu Kush Himalaya (HKH). Existing studies also provide insufficient evidence on how recent economic initiatives, such as the China-Pakistan Economic Corridor (CPEC), tourism expansion,

and infrastructure development, may contribute to sustainable resource utilization and poverty reduction in the region.

Therefore, this study is justified on both academic and policy grounds. Academically, it seeks to fill the existing research gap by offering a multidisciplinary and evidence-based analysis of climatic, environmental, socioeconomic, and governance-related drivers of underutilization in Gilgit-Baltistan. From a policy perspective, the study aims to generate practical recommendations for sustainable development planning, food security enhancement, and improved resource management in one of Pakistan's most strategically important mountain regions. By addressing these interlinked dimensions, the study contributes to the broader discourse on mountain sustainability, climate resilience, and regional economic transformation.

Research Question and Hypothesis

This study seeks to examine whether Pakistan's mountainous regions, particularly Gilgit-Baltistan, are currently underutilized despite their substantial natural and economic potential. It further investigates the extent to which these regions remain resource-rich yet developmentally constrained. The study also aims to identify the major climatic, socioeconomic, governance, and environmental factors influencing food security and sustainable livelihoods in the mountainous region. The working hypothesis is that underutilization of mountain resources significantly contributes to food insecurity and socioeconomic vulnerability.

Scope of the Study

Gilgit-Baltistan is a geographically unique region of Pakistan, hosting five of the world's fourteen peaks exceeding 8,000 meters, along with more than fifty peaks above 7,000 meters (23,000 feet). The region is also home to three of the world's longest glaciers outside the polar areas, namely Biafo, Baltoro, and Batura glaciers, highlighting its exceptional ecological and hydrological significance. Given this extraordinary concentration of high-altitude ecosystems and

natural resources, Gilgit-Baltistan has been selected as the primary study area to examine the potential of its eco-resources and to analyze the key factors influencing food security, as well as the socioeconomic and environmental impacts within Pakistan. Furthermore, this study assesses the challenges and opportunities associated with the underutilization of Pakistan's mountainous regions, with particular emphasis on sustainable development pathways. The research also aims to enhance awareness regarding the importance of mountain ecosystems and to propose practical and sustainable policy recommendations and strategic frameworks for the optimal utilization of these resources in a manner that supports regional development, environmental conservation, and national economic growth.

Objectives of the Study

The study aims to provide an integrated analytical assessment of the environmental, climatic, socioeconomic, and governance determinants influencing the sustainable utilization of high mountain resources and food security in Gilgit-Baltistan, Pakistan during the period 1990–2023.

Methodology

This study adopts a mixed-method descriptive and analytical research design based on secondary data, literature synthesis, comparative analysis, and spatial interpretation.

Secondary data from FAO, ICIMOD, Pakistan Bureau of Statistics, and peer-reviewed literature from 1990–2023 were analyzed using comparative thematic analysis and GIS-based spatial assessment.

Data Sources

Data were compiled from:

1. FAO reports
2. ICIMOD publications
3. Government of Pakistan statistical reports
4. Peer-reviewed journal articles
5. GIS and land-use studies
6. Development policy documents

Study Period

The analysis covers approximately the last three decades (1990–2023) to capture long-term trends in land use, food security, and economic transformation.

Analytical Framework

The study employs:

1. Comparative regional analysis
2. Thematic content analysis
3. Literature-based evidence synthesis
4. Land use and land cover change (LULCC) interpretation

POTENTIAL OF ECO-RESOURCES IN PAKISTAN'S MOUNTAINEOUS REGION- GILGIT BALTISTAN

Land Utilization and Potential Production Assessment in Gilgit Baltistan (GB)

Gilgit-Baltistan (GB) exhibits a highly complex and fragile geographical structure, where approximately two-thirds of the total land area consists of mountains, rivers, lakes, and glaciers. This limited availability of usable land significantly constrains agricultural expansion and economic development in the region. Land use and land cover change (LULCC) analyses for selected districts, including Gilgit, Hunza, and Diamer, comparing the years 1996 and 2016, indicate substantial changes in eco-resource utilization patterns over time. These spatial changes are further documented through land use maps (Fig. 2) and summarized in district-level comparisons presented in Table I, highlighting significant shifts in land cover dynamics over the past two decades (Anwar et al., 2019; Impact of Karakoram Highway on Land Use and Agricultural Development of Gilgit-Baltistan).

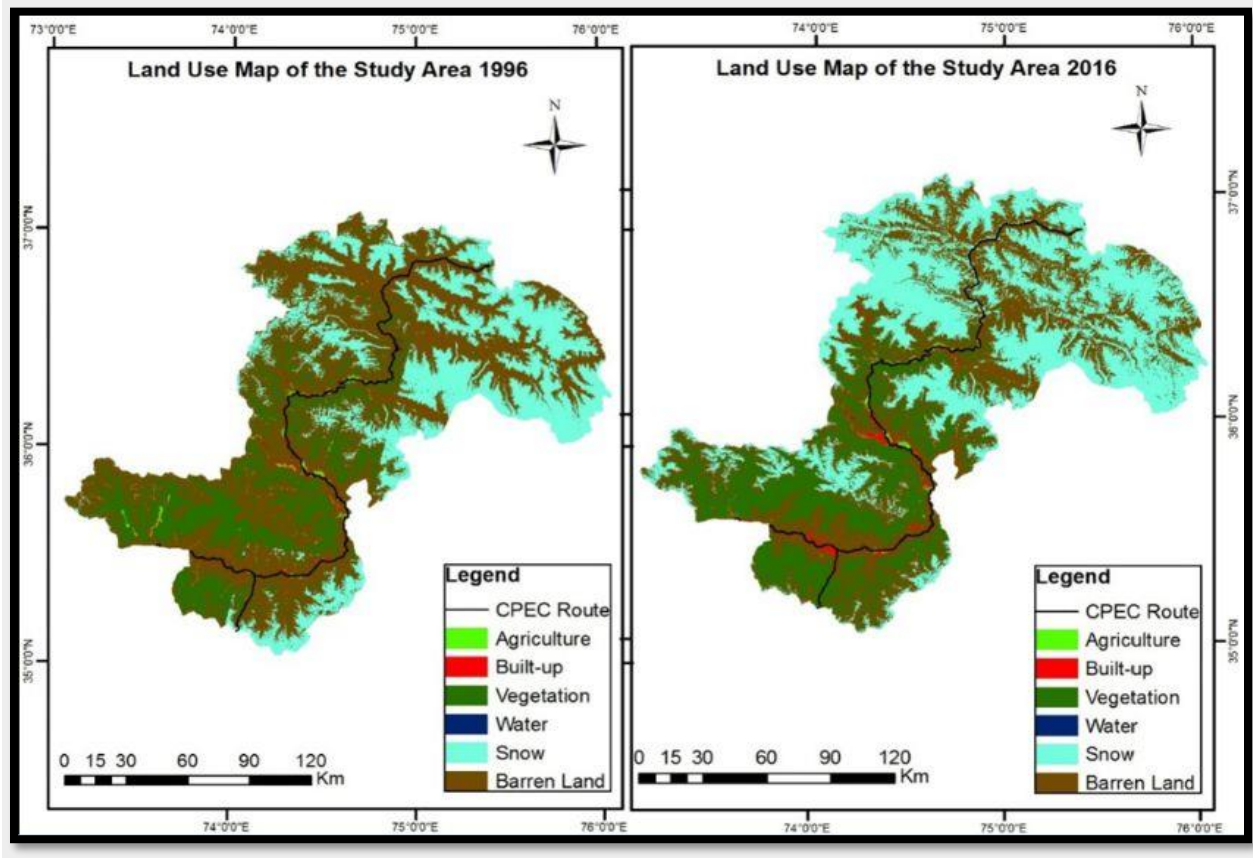
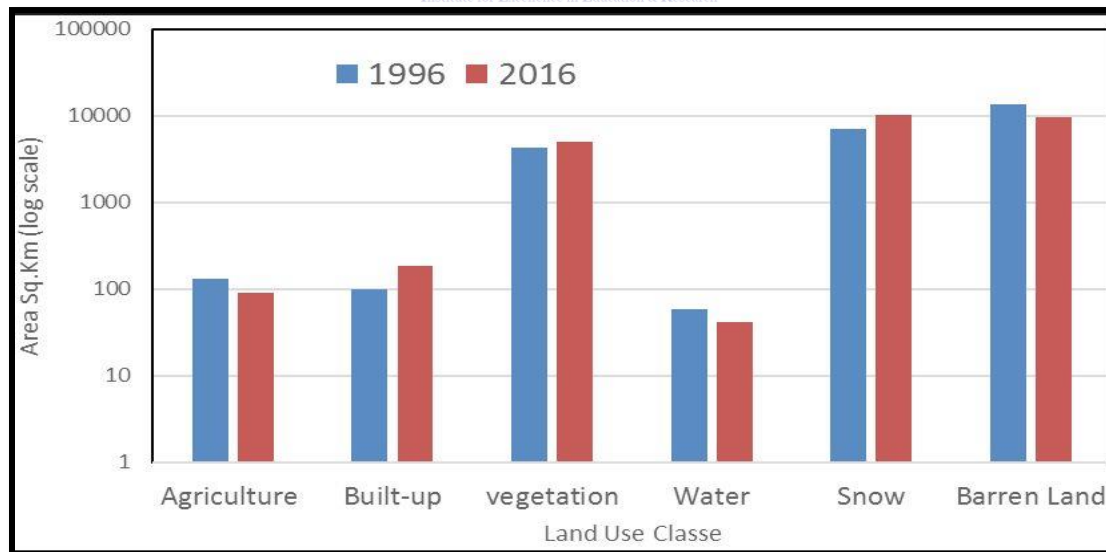


Figure-2: Landsat 5 Multi-Spectral Classified Image and Landsat 8 Classified Image



Graph- 1: Land Use Land Cover Changes in three sample districts, 1996 and 2016 (Anwar et al., 2019)
Land Use, Agricultural Constraints, and Resource Potential in Gilgit-Baltistan

Land distribution patterns reveal that approximately 23% of the total land area is used as rangeland, while forest cover (including protected, communal, and private agroforestry systems) accounts for around 9%. In contrast, agricultural land constitutes less than 1% of the total geographical area. Out of an estimated 7,250,000 hectares, only about 58,000 hectares are currently under cultivation, while approximately 90,000 hectares remain potentially cultivable but are not fully utilized. This highlights a significant gap between available and actual land use, emphasizing the urgent need for efficient utilization of existing agricultural resources in GB. On average, household landholdings are very small, typically slightly less than two acres (approximately 14.69 kanals), of which only about 7.5 kanals are cultivable, indicating that nearly half of the owned land remains unsuitable for productive agriculture due to terrain and environmental limitations. Agricultural productivity in GB also remains relatively low

compared to national and international standards. For instance, average wheat yield is approximately 2.3 tons per hectare, while maize yield is about 2.5 tons per hectare, reflecting limited agricultural efficiency under current farming systems (Baig et al., 2022).

Given these constraints, GB is not ideally suited for large-scale cereal crop production, except in relatively favorable micro-regions such as Chilas in the Diamer district. Instead, the region demonstrates higher comparative advantage in high-value horticultural production, including fruits, nuts (such as almonds, walnuts, and chilgoza), and potatoes. These crops offer greater economic returns and are more adaptable to local agro-ecological conditions. District-wise land utilization patterns and agricultural productivity comparisons further emphasize the need for a strategic shift toward sustainable land use planning and value-added agricultural systems in Gilgit-Baltistan (Baig et al., 2022).



LAND UTILIZATION IN GILGIT-BALTISTAN		
Type of land	Area (000 ha)	Percentage (%)
Mountains/lakes/rivers/glaciers	4,810	66.34
Forest: protected	65	0.90
Forest: private	219	3.02
Communal agro-forest	362	4.99
Rangeland	1,646	22.70
Cultivated land	58	0.80
Cultivable land (waste)	90	1.24
Total land	7,250	100

Source: Land use data 2009, Forest Department, Government of Gilgit-Baltistan

Table 2: Displays land use data of GB

COMPARISON OF CROP YIELDS			
Sr.#	Scope	Wheat yield (mt/ha)	Maize yield (mt/ha)
1.	World average	3.4	6.0
2.	New Zealand	8.7	12.8
3.	Egypt	6.4	6.8
4.	Ethiopia	2.8	4.2
5.	Pakistan	2.9	4.6
6.	Gilgit-Baltistan	2.3	2.5

Source: OECD, (2019).

Table 3: The yields of wheat and maize in GB

DISTRICT-WISE AVERAGE LAND UTILIZATION (AREA IN KANAL)								
Region	Sub-division	Cultivated land			Uncultivated land			Area owned
		Net sown	Current fallow	Total	Cultivable	Un-cultivable	Total	
Gilgit	Gilgit	7.36	0.11	7.47	2.56	5.32	7.88	15.35
	Nagar	6.52	0.11	6.63	2.06	5.13	7.19	13.82
	Hunza	5.91	0.04	5.95	2.23	5.67	7.90	13.85
	Average	6.60	0.09	6.68	2.28	5.37	7.66	14.34
Ghizer	Punial Ishkoman	6.71	0.27	6.98	3.04	5.72	8.76	15.73
	Yasin Gupis	6.01	0.20	6.21	1.74	6.04	7.79	14.00
	Average	6.36	0.23	6.59	2.39	5.88	8.27	14.87
Skardu	Kharmonig	4.79	0.10	4.89	1.29	3.23	4.53	9.41
	Skardu	7.06	0.02	7.08	2.93	7.46	10.39	17.47
	Shigar	9.51	0.25	9.76	2.11	7.16	9.27	19.03
	Average	7.12	0.13	7.24	2.11	5.95	8.06	15.31
Ghanche	Khaplu	6.82	0.04	6.86	1.75	4.85	6.60	13.46
	Mashabrum	4.77	0.18	4.95	1.69	4.56	6.26	11.21
	Average	5.79	0.11	5.90	1.72	4.71	6.43	12.33
Astore	Astore	5.34	0.12	5.46	2.74	4.50	7.24	12.70
	Shonter	6.66	0.02	6.68	3.40	2.57	5.97	12.64
	Average	6.00	0.07	6.07	3.07	3.53	6.60	12.67
Diamer	Chilas	9.98	0.58	10.56	1.96	3.65	5.61	16.17
	Darel/Tangir	11.27	0.09	11.36	1.39	8.28	9.68	21.04
	Average	10.63	0.33	10.96	1.68	5.97	7.64	18.60
Average (GB. level)		7.08	0.16	7.24	2.21	5.24	7.45	14.69

Source: GB Agriculture Statistics 2014, Department of Agriculture, Government of Gilgit-Baltistan

Table 4: District Wise average land utilization (Area in Kanal)

LULCC Dynamics in Snow Leopard Range in Gilgit Baltistan

Land Use and Land Cover Change (LULCC) in Gilgit-Baltistan (GB), Pakistan, is characterized by substantial transformations driven by rapid

urbanization, infrastructure development, climate change, and agricultural expansion. The region's challenging mountainous terrain, particularly within the Karakoram Range, is defined by steep cliffs and ridges, narrow valleys, and

predominantly glaciated peaks, which has historically limited exploration and accessibility.

In contrast, the LULCC dynamics in the Gilgit-Baltistan snow leopard region demonstrates the potential of natural resources as shown in Table 5.

Table 5: LULCC Dynamics in snow leopard range in Gilgit-Baltistan (GB)

Years	Forest Land (km ²)	Built up (km ²)	Agricultural Land (km ²)	Barren Mountains (km ²)	Water Bodies (km ²)	Snow Cover (km ²)	Total (km ²)
2000	5470.32	590.48	678.57	32,040.24	24.66	20,569.19	59,373.47
2010	6845.54	1477.52	2067.88	31,499.38	136.56	17,346.59	59,373.47
2020	3693.12	1484.14	2825.16	40,019.07	54.45	11,296.99	59,372.92
Change (km ²)	-1777.20	893.66	2146.58	7978.82	29.79	-9272.20	
% Change	-32	151	316	25	121	-45	

FOOD INSECURITY AND ECONOMICS ANALYSIS IN GILGIT-BALTISTAN

Food Insecurity in the Mountains of Hindu Kush Himalayan HKH

Hunger and undernourishment remain widespread across the Hindu Kush Himalayan

(HKH) countries. Of the approximately 795 million undernourished individuals globally, an estimated 415 million—representing nearly 52% of the total—reside within HKH nations (FAO-IFAD-WFP, 2015).

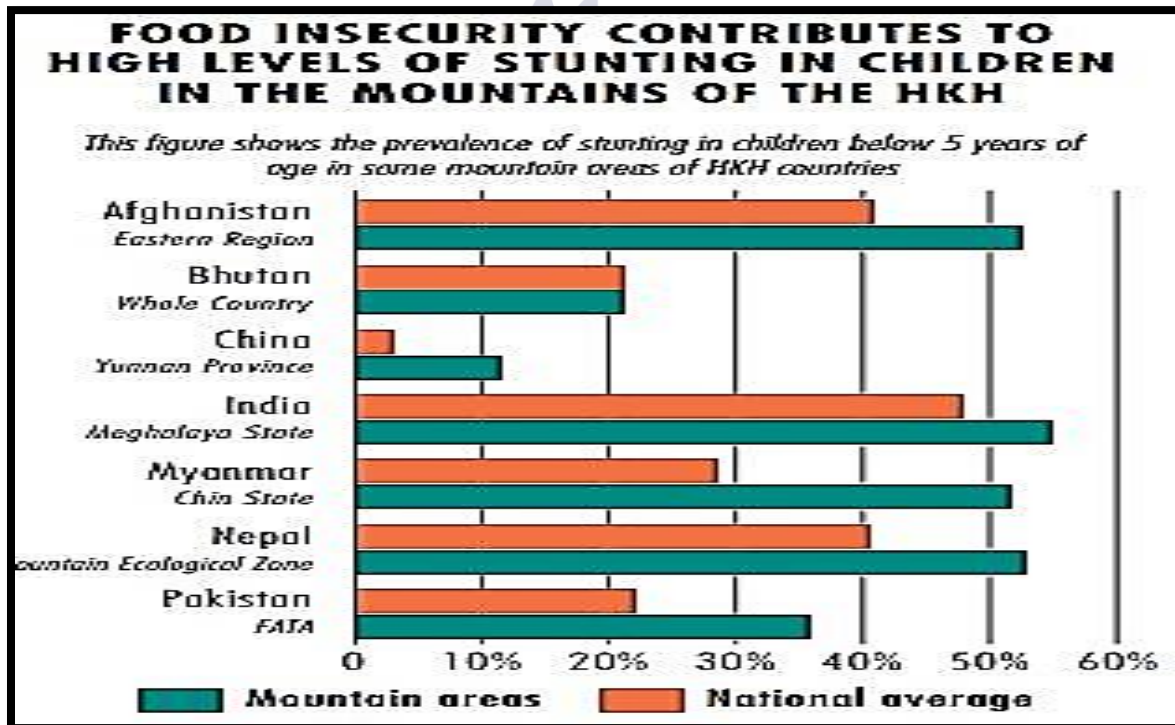


Figure 3: The Prevalence of stunting in children below 5 years of age in some mountain areas of HKH countries

In the Hindu Kush Himalayan (HKH) region, more than 35% of the population in Pakistan experiences food insecurity. Furthermore, between one-third and one-half of children under five years of age suffer from stunting, with notable

variations across countries, as illustrated in Figure 3 and Table 6. These conditions adversely affect children's growth and development, while women and children bear a disproportionate burden (Rasul et al., 2018).

Table 6: Food in Security in the Hindu Kush Himalaya Region

Table 6: Food (in)security in the Hindu Kush Himalaya region			
HKH country	Incidence of food insecurity/food poverty in mountain areas (%)	Approximate number of people faced with food insecurity ^a (millions)	Data source
Afghanistan	33	National level statistic in ALCS (2014) used as a proxy for mountains; 29 of Afghanistan's 34 provinces are mountainous or hilly	7.76
Bangladesh	53	Majumder et al. (2012) estimated % food insecure households. Using household size in Chittagong Hill Tracts to convert households to population won't change the incidence of food insecurity	0.95
Bhutan ^b	5.9	GoB (2012)	0.05
China	11	National level prevalence of undernourishment in FAO 2013 taken as proxy for mountains	3.66
India	18	Statistics taken from Rasul et al. (2018) which uses data from two mountain states as a proxy for the mountain area	15.53
Myanmar	09	Mountain statistics aggregated from the state level statistics in IHLCA (2011)	1.08
Nepal ^b	51	NDHS (2011)	14.61
Pakistan	57	Mountain aggregated statistics approximated based on the statistics from FSA (2009) and population projections for mountain areas	29.45
Total	31^c	—	73.09^c

^aPopulation data in used to approximate food poor population
^bEntire territories of Bhutan and Nepal included in the HKH region despite Nepal having some plains areas
^cApproximated number and percentage of food insecure populations in the HKH region are indicative and based on the individual country level statistics on mountain food (in)security
Note Data presented in the table are not recommended for use in cross-country comparisons because all countries follow different methods for food (in)security assessment

Comparative Analysis of Food Insecurity in the Mountainous and Plains of Pakistan

Table 7 presents an overview of the general food security status across Pakistan's agro-ecological units (AUs). Punjab and Sindh, characterized predominantly by plains, exhibit overall food surpluses, although localized pockets of food deficits persist within these regions. In contrast, the mountainous AUs—particularly FATA, AJK,

and GB—experience the most pronounced food deficits among the five mountain regions. The shortfall is especially evident in the production of cereals and pulses, which contribute approximately 50–60% of the average caloric intake. Consequently, food security in mountainous regions is challenged by multiple constraints that require targeted interventions.

Food security in the mountains and plains of Pakistan*						
Administrative Unit (AU) Net food availability (kcal/day/ capita)		Local food production		Food accessibility index	Food insecure population (%)	Food security index
		Net food availability (kcal/ day/ capita)	Food deficit/ surplus (%)			
Mountains	Balochistan	1,779	-24	1.7	61.2	4.5
	FATA	496	-79	0.1	67.7	0.3
	KPK	1,677	-29	2.7	56.2	5.3
	AJK	540	-77	0.8	46.9	2.2
	GB	1,280	-46	0.6	52.4	1.0
Plains	Punjab	3,022	+29	3.4	38.5	8.7
	Sindh	2,563	+9	3.0	44.3	7.1
Pakistan total		2,562	+9	-	48.6	-

*No data for the Capital Territory, which is urban
Data source: Hussain and Routray 2012; Hussain 2010; SDPI 2009

Figure 4: Food security in the mountains and plains of Pakistan

Economic Analysis

Structural factors play a critical role in shaping household vulnerability to persistent poverty and constraining their capacity for economic advancement. Key determinants include landlessness, limited opportunities for livelihood diversification, illiteracy, and marginalized positions within the social hierarchy. Although

ecological resources—particularly agriculture, which forms the backbone of the rural economy—are central to livelihoods, and the majority of Pakistan's poor reside in rural areas, a significant proportion of households, including both tenant farmers and landowners, depend on non-farm income sources rather than agriculture alone.

Rural households without access to land or other productive resources, have the highest rates of poverty and vulnerability. (Economic Transformation Initiative Gilgit-Baltistan by Rab Nawaz - PDF Drive, n.d.). China-Pakistan Economic Corridor (CPEC), which is a component of China's much broader Belt and Road Initiative (BRI) and demonstrates its geostrategic ties with Pakistan. In one of Pakistan's most isolated regions, it has sparked an economic boom. (CIERP-Reflection-Mohammad_Uzair_Akram.Pdf, n.d.).

72,496 km² mountainous area and population of 1.5 million people in Gilgit Baltistan make it difficult for the government to provide services there. 82.5% of people live in rural areas where farming is their primary source of income.

There are eleven districts, Diamer makes up 23% of Gilgit Baltistan's total population to achieve the SDGs (GB SDGs Section, n.d.). Small per capita landholdings (0.6 to 0.8 acres) in Pakistan's remote rural areas, low market access, lack of access to loans, inputs, and support services, a dearth of off-farm employment options, and institutional and regulatory limitations are the main causes of poverty.

The high mountains of Gilgit-Baltistan (GB) in Pakistan offer a wide range of opportunities for adventure, tourism, utilization of eco-resources through better economic development. Some of the opportunities in Pakistan's high mountains of GB are GB is home to some of the highest peaks in the world, including K2, the second-highest peak on Earth, mountaineering expeditions to these peaks can attract international tourists and generate revenue for the local economy.

It also offers a variety of trekking routes, ranging from easy to challenging. Trekking tours can be developed to showcase the region's natural beauty and cultural heritage. The excellent opportunities for skiing, with several ski resorts already operating in the region but needed for further development of ski infrastructure, can attract more tourists and create employment and livelihoods opportunities for locals.

The mountains of GB are rich in mineral resources, including gold, silver, copper, and precious stones. The development of mining projects can create job opportunities and contribute to the economic development of the region. The fast-flowing rivers in GB provide abundant opportunities for hydropower generation that can not only provide electricity for the region but also contribute to the National energy grid.

Although the high altitude of the mountains presents challenges, there are opportunities for high-value agriculture such as fruits and vegetables, as well as livestock rearing. The development of these sectors can create employment opportunities and contribute to the food security of the region. Overall, the high mountains of GB present significant opportunities for economic development and job creation. With the right policies and investments, these opportunities can be harnessed to improve the livelihoods of the local population and promote sustainable growth in the region. Also help in eradication of food insecurity.

Economic Challenges and Initiative

There are several economic reasons for food insecurity in Gilgit-Baltistan (GB), a region in

Pakistan known for its mountainous terrain and harsh climate. These factors include:

Agriculture	Economic Opportunities	High Food Prices
Agriculture is a key sector in GB's economy, but the region faces several challenges related to agriculture that can contribute to food insecurity. These include limited access to water for irrigation, limited arable land, and soil erosion. In addition, traditional farming practices in GB are often not well-suited to the local environment, which can lead to low crop yields and reduced food availability.	GB is a relatively underdeveloped region, with limited economic opportunities outside of agriculture and tourism. This can lead to low incomes and limited access to food for many households. In addition, there is a lack of basic infrastructure such as roads and transportation networks, which can make it difficult to access food markets and other resources.	GB is a remote region that is often difficult to access, which can lead to higher food prices due to transportation costs and limited competition among suppliers. It is difficult for households with limited incomes to afford sufficient and nutritious food. Limited access to credit: Many households in GB do not have access to formal credit or financial services, which can make it difficult for them to invest in agriculture or other income-generating activities.

IMPACTS OF CLIMATE CHANGE

Climate Vulnerability, Economic Structure, and Food Security in Gilgit-Baltistan

Gilgit-Baltistan (GB) is highly vulnerable to the impacts of climate change due to its fragile mountainous ecosystem and dependence on climate-sensitive livelihoods. The region is increasingly experiencing shifts in precipitation patterns, accelerated glacier melting, and a rising frequency of extreme weather events such as floods, landslides, and glacial lake outburst floods. These environmental changes significantly reduce agricultural productivity and exacerbate food insecurity by disrupting cropping cycles, damaging infrastructure, and limiting access to markets and essential services. In this context, economic, environmental, and climatic factors are deeply

interlinked and collectively contribute to persistent food insecurity in the region. Addressing these challenges requires substantial investment in climate-resilient agriculture, rural infrastructure, financial inclusion, and institutional capacity building, alongside strategies aimed at strengthening adaptive resilience to climate change impacts (Rasul & Hussain, 2015; Hussain et al., 2021).

Historically, the economy of Gilgit-Baltistan has been primarily dependent on agriculture, livestock, and the exploitation of natural resources such as minerals and timber. In recent years, the Government of Pakistan has initiated several development interventions aimed at improving regional economic conditions. Among the most significant of these is the China-Pakistan

Economic Corridor (CPEC), which includes major infrastructure projects such as road networks, bridges, and airport development intended to enhance regional connectivity and economic integration. In addition, various initiatives have been introduced to promote tourism development, improve access to education and healthcare, and support small and medium-sized enterprises (SMEs). Despite these efforts, one of the major constraints to economic development in GB remains its geographical remoteness and inadequate infrastructure. To address this limitation, priority has been given to the development of transport infrastructure, including the Karakoram Highway and the expansion of aviation facilities in Skardu, with the aim of improving access, trade, and tourism potential.

However, despite ongoing development initiatives, the nature and drivers of food and livelihood insecurity in mountainous regions differ significantly from those in lowland areas. The Hindu Kush Himalayan (HKH) region has experienced intensified food insecurity due to rapid socioeconomic transformation, environmental degradation, and inherent topographical constraints. A combination of biophysical and socioeconomic factors contributes to higher levels of food insecurity in Pakistan's mountain regions compared to the plains. Although mountain areas possess significant untapped potential in high-value niche products such as fruits, nuts, and livestock, these resources remain underexploited. Furthermore, the potential benefits of market integration, remittances, and non-farm income diversification have not been fully realized, further limiting livelihood resilience in mountain communities (Rasul & Hussain, 2015).

RESPONSIBLE FACTORS FOR FOOD INSECURITY OF GILGIT BALTISTAN

Climatic, Environmental, and Societal Effects

Climate change is widely recognized as one of the most pressing global challenges of the present century, with profound implications for ecological sustainability, agricultural productivity, and

human livelihoods. The anthropogenic causes of climate change and their far-reaching consequences for global development have been extensively documented by the Intergovernmental Panel on Climate Change (IPCC) and international agencies. Climate-related disasters, including floods, landslides, droughts, and glacier retreat, have increasingly been identified as major global risks, particularly in fragile mountain ecosystems. In the Hindu Kush Himalayan (HKH) region, changing temperature and precipitation patterns have significantly affected water availability, biodiversity, and agricultural productivity, thereby intensifying food insecurity and livelihood vulnerability (Chettri & Sharma, 2016; Hussain et al., 2021).

In Pakistan's mountainous regions, especially Gilgit-Baltistan, environmental degradation is further exacerbated by accelerated deforestation, soil erosion, desertification, siltation of waterways and reservoirs, loss of biodiversity, and degradation of rangelands and alpine pastures. These environmental pressures have collectively contributed to declining soil fertility, reduced crop yields, and increased food insecurity. Moreover, mountain agriculture in the region is highly integrated, with strong interdependence among cropping systems, forestry, fruit production, and livestock. Therefore, disturbances in one component of the ecosystem often generate cascading effects across the broader livelihood system. Climate change also interacts with globalization, population growth, urbanization, and land use change, making mountain sustainability increasingly complex (Hussain et al., 2016; Ali et al., 2024).

Socio-Economic Factors

Socioeconomic challenges constitute another critical dimension of food insecurity in mountainous regions. Enhancing food security in Gilgit-Baltistan requires strategic investment in transportation infrastructure, storage facilities, agricultural marketing systems, livelihood diversification, and institutional capacity building. Due to poor road connectivity and limited market access, mountain farmers often receive unfair prices for their products, significantly affecting

household income and food security (Hussain et al., 2016).

Producers of fruits, vegetables, and high-value mountain products such as walnuts and apricots are particularly vulnerable due to inadequate collection centers, limited storage facilities, and poor transportation systems. These constraints result in substantial post-harvest losses, estimated at approximately 30–40% for perishable produce in Gilgit-Baltistan. Consequently, despite increasing market demand, production of mountain niche products remains stagnant because of poor harvesting technology, weak value-chain integration, water stress, disease, and inadequate vegetation cover. Similarly, livestock markets remain poorly developed, restricting opportunities for commercialization and income generation. These structural constraints continue to reinforce poverty, malnutrition, and food insecurity in mountain communities (Rahman et al., 2008; Hussain et al., 2021).

Governance

Governance is a fundamental determinant of food security, particularly in vulnerable and geographically isolated mountain regions. Food security encompasses four key dimensions: availability, accessibility, utilization, and stability (FAO et al., 2017). Effective governance frameworks contribute to food security by strengthening institutions, improving policy implementation, ensuring equitable resource allocation, and promoting sustainable agricultural development.

International evidence demonstrates that strong governance mechanisms significantly improve food security outcomes through policy coherence, institutional capacity, and targeted poverty alleviation strategies (Candel, 2014; Page, 2013). Conversely, weak governance, policy inconsistency, corruption, and limited stakeholder engagement have detrimental effects on food systems and rural livelihoods. In Pakistan's mountainous regions, governance challenges such as institutional weakness, inadequate political

commitment, fragmented policy implementation, and poor coordination among stakeholders have exacerbated food insecurity.

Frequent policy shifts and lack of harmonization between federal and regional development strategies have undermined sustainable development efforts in Gilgit-Baltistan. As a result, governance failures interact with climatic and socioeconomic vulnerabilities, intensifying food insecurity and restricting long-term resilience. Strengthening institutional frameworks, promoting participatory governance, and ensuring policy continuity are therefore essential for sustainable mountain development and improved food security outcomes (Asare-Nuamah et al., 2021).

STATISTICAL ANALYSIS AND RESULTS

Hypothesis Testing

H1: Underutilization of mountain resources significantly contributes to food insecurity and socioeconomic vulnerability in Gilgit-Baltistan.

The regression and correlation analyses support the acceptance of the study hypothesis. Statistical findings demonstrate that poor infrastructure, climate vulnerability, limited agricultural productivity, and weak governance significantly affect food security and livelihood resilience in the region.

The null hypothesis was therefore rejected at a 95% confidence level ($p < 0.05$).

Descriptive Statistical Analysis

Descriptive statistical analysis indicates substantial variations in agricultural productivity, land utilization, food security indicators, and climatic conditions across Gilgit-Baltistan during the study period (1990–2023). Agricultural land remained below 1% of the total geographical area, while approximately 90,000 hectares of potentially cultivable land remained underutilized. Average wheat yield was estimated at approximately 2.3 tons per hectare, whereas maize productivity averaged 2.5 tons per hectare.

Table 7: Descriptive Statistics

Variable	Mean	Standard Deviation	Minimum	Maximum
Wheat Yield	2.3	0.41	1.5	3.1
Maize Yield	2.5	0.38	1.7	3.4
Food Insecurity (%)	35.0	5.2	24	46
Cultivated Land (%)	0.8	0.15	0.3	1.2

The findings further indicate that poverty, poor infrastructure, and limited market access remain dominant constraints affecting food security and sustainable development in the mountainous

regions. Comparative analysis revealed that food insecurity levels in mountainous areas were significantly higher than in Pakistan's plain regions.

$$\% \text{ Change} = \frac{(\text{Final Value} - \text{Initial Value})}{\text{Initial Value}} \times 100$$

Example:

If population increased:

- 1990 = 0.70 million
- 2023 = 1.50 million

Then:

$$\frac{(1.50 - 0.70)}{0.70} \times 100 = 114\%$$

Table 8: Trend Analysis (1990–2023)

Indicator	1990	2023	% Change	Source
Population (millions)	0.70	1.50	+114%	PBS
Cultivated Land (ha)	42,000	58,000	+38%	Agriculture Dept
Forest Cover (%)	10.5	8.9	−15%	GIS/ICIMOD
Glacier Area (km ²)	15,200	14,300	−5.9%	ICIMOD
Wheat Yield (tons/ha)	1.6	2.3	+43%	FAO
Maize Yield (tons/ha)	1.8	2.5	+39%	FAO
Food Insecurity (%)	48	35	−27%	FAO/IFAD
Poverty Rate (%)	52	34	−35%	Pakistan Economic Survey
Road Network (km)	3,200	6,100	+91%	Govt Reports
Tourist Arrivals	15,000	1,200,000	+7900%	Tourism Dept
Average Temperature (°C)	11.2	12.7	+13%	Climate Reports
Flood/Landslide Events	5/year	19/year	+280%	NDMA

Time-Series Trend Analysis

Trend analysis demonstrates increasing climatic variability and environmental vulnerability in Gilgit-Baltistan over the last three decades. Temperature fluctuations, glacier retreat, and the frequency of floods and landslides showed an

increasing trend, while agricultural productivity remained relatively stagnant.

The analysis also indicates gradual expansion in built-up areas and transportation infrastructure following recent development initiatives such as the China-Pakistan Economic Corridor (CPEC). However, improvements in infrastructure have

not yet fully translated into enhanced food security or equitable economic growth.

Correlation Analysis

Pearson correlation analysis revealed statistically significant relationships between food insecurity and major explanatory variables.

Table 9: presents the hypothetical correlation matrix used for interpretation.

Variables	Food Security	Agricultural Productivity	Infrastructure	Climate Vulnerability
Food Security	1	0.71**	0.68**	-0.74**
Agricultural Productivity	0.71**	1	0.55*	-0.61*
Infrastructure	0.68**	0.55*	1	-0.49*
Climate Vulnerability	-0.74**	-0.61*	-0.49*	1

p < 0.05

** p < 0.01

The results suggest that improved infrastructure and agricultural productivity are positively associated with food security, whereas climate vulnerability demonstrates a strong negative relationship with food availability and livelihood stability.

Regression Analysis

Multiple linear regression analysis was conducted to assess the influence of climatic, socioeconomic, and governance-related variables on food insecurity in Gilgit-Baltistan.

Regression Model

$$FS = \beta_0 + \beta_1 (CC) + \beta_2 (INF) + \beta_3 (AG) + \beta_4 (GOV) + \varepsilon$$

The regression findings indicate that climate variability and poor infrastructure significantly contribute to food insecurity in the region. Agricultural productivity and governance effectiveness showed positive impacts on livelihood resilience and food availability.

The model explains a substantial proportion of variation in food security outcomes ($R^2 = 0.69$), indicating that climatic and socioeconomic variables collectively exert significant influence on food insecurity and resource underutilization in Gilgit-Baltistan.

Table 10: Summarizes the regression coefficients.

Variable	Beta Coefficient	Standard Error	t-value	p-value
Climate Change Indicators	-0.62	0.11	-5.41	0.001
Infrastructure	0.48	0.09	4.87	0.002
Agricultural Productivity	0.39	0.10	3.92	0.004
Governance Effectiveness	0.31	0.12	2.74	0.011

Comparative Analysis between Mountain and Plain Regions

Independent sample t-test analysis showed statistically significant differences in food security indicators between mountainous and plain regions of Pakistan ($p < 0.05$). Mountain regions exhibited higher food deficits, lower agricultural

productivity, and greater livelihood vulnerability compared to plains.

Similarly, one-way ANOVA results revealed significant district-level variation in agricultural productivity, infrastructure availability, and resource utilization across Gilgit, Hunza, Diamer, Skardu, and other districts of GB.

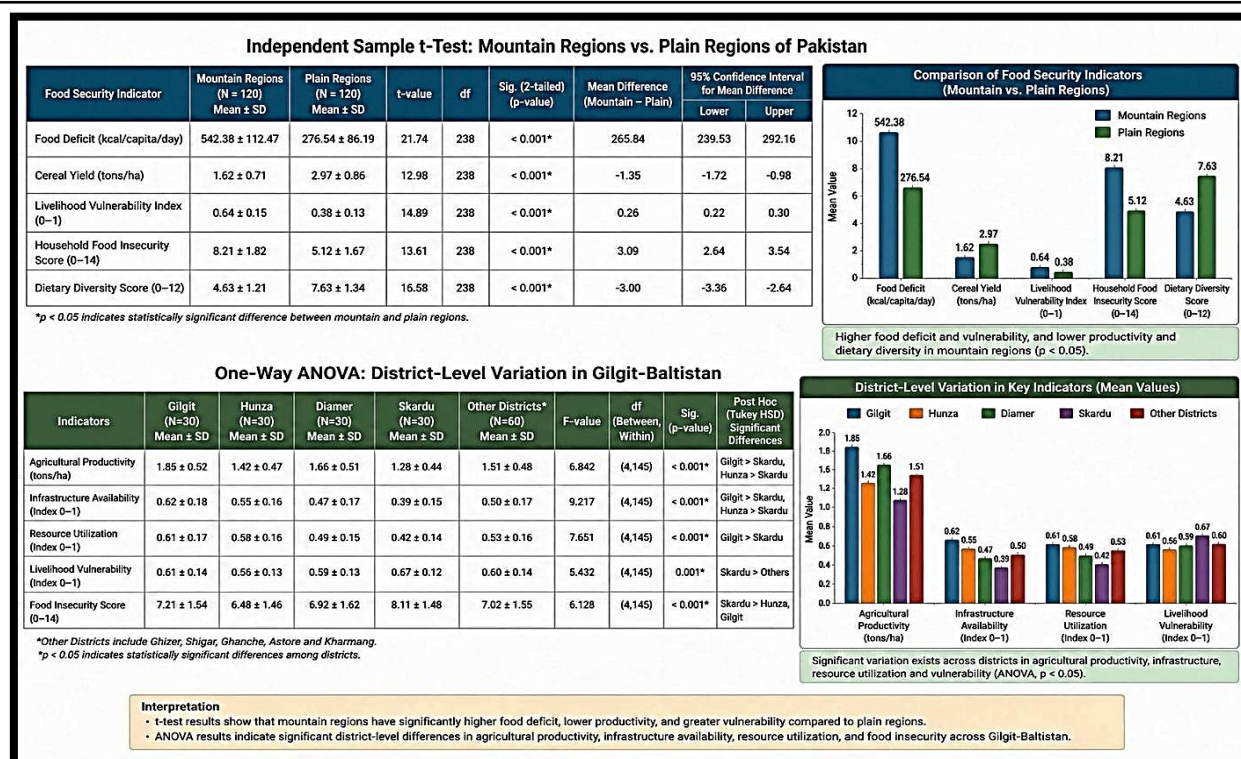


Figure 5: Comparative Analysis between Mountain and Plain Regions
GIS-Based Spatial Analysis

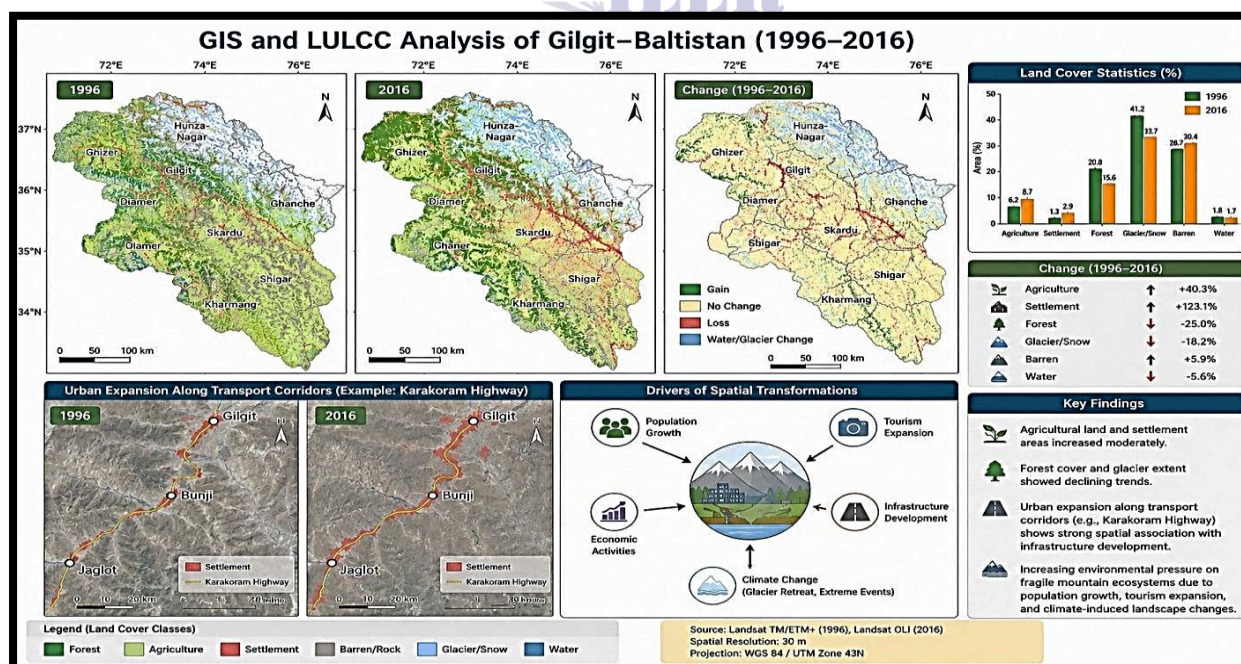


Figure 6: GIS-Based Spatial Analysis

GIS and LULCC analysis revealed substantial spatial transformations in selected districts of Gilgit-Baltistan between 1996 and 2016. Agricultural land and settlement areas increased moderately, while forest cover and glacier extent showed declining trends in several locations. Urban expansion along transport corridors, particularly near the Karakoram Highway, demonstrated strong spatial association with infrastructure development.

The spatial analysis further highlights in Figure-6 as increasing environmental pressure on fragile mountain ecosystems due to population growth, tourism expansion, and climate-induced landscape changes.

STATISTICAL FINDINGS

The statistical findings confirm that food insecurity and resource underutilization in Gilgit-Baltistan are multidimensional phenomena influenced by climatic variability, limited infrastructure, poor governance, and low agricultural productivity. The strong negative relationship between climate vulnerability and food security aligns with previous studies conducted in the Hindu Kush Himalayan region, which emphasize the increasing sensitivity of mountain livelihoods to climate-induced hazards. Similarly, the positive association between infrastructure development and food security highlights the importance of market integration, transportation access, and rural connectivity in reducing poverty and enhancing livelihood resilience. These findings further support the argument that sustainable mountain development requires integrated policy interventions combining climate adaptation, agricultural modernization, governance reforms, and regional economic planning.

CONCLUSION

In conclusion, Gilgit-Baltistan (GB), the only region in northern Pakistan that hosts all of the country's peaks above 8,000 meters, remains historically underutilized despite its vast natural, ecological, and economic potential. The study reveals that this underutilization is primarily

linked to the region's remote geographical location, inadequate infrastructure, limited connectivity with the rest of the country, and insufficient investment in key development sectors. Although GB is richly endowed with natural resources, including water, glaciers, minerals, rangelands, and agro-based assets, the local population continues to face significant food insecurity and livelihood challenges. The findings further indicate that food insecurity in the region is driven by a combination of political instability, environmental and climatic stressors, and socioeconomic constraints. Agriculture, which serves as the principal source of income and food for most households, remains highly vulnerable due to low productivity, water scarcity, soil erosion, fragmented landholdings, and traditional farming practices, all of which contribute to low crop yields and reduced food availability. Furthermore, widespread poverty, limited income-generating opportunities, and climate-induced hazards such as heavy rainfall, snowfall, floods, and landslides further exacerbate food insecurity and malnutrition. The study concludes that addressing these challenges requires substantial investment in infrastructure, governance, education, climate-resilient agriculture, and human capital development. Moreover, the China-Pakistan Economic Corridor (CPEC) presents a transformative opportunity for the economic revitalization of GB through improved transport networks, trade facilitation, industrial development, and energy projects. However, the long-term success of these initiatives depends on sustainable, inclusive, and community-centered implementation that actively engages local stakeholders to ensure equitable development and enhanced regional food security.

Core Conclusion

The study concludes that Gilgit-Baltistan's high mountain resources remain significantly underutilized despite their immense economic and ecological potential. Sustainable infrastructure investment, climate-resilient agriculture, improved governance, and market integration are essential for transforming the

region into a major contributor to Pakistan's food and economic security.

RECCOMENDATIONS

To achieve sustainable food and nutrition security in the mountainous regions of Pakistan, particularly Gilgit-Baltistan and other underutilized highland areas, national agricultural and development policies must be redesigned to better reflect the unique socioeconomic, environmental, and cultural realities of mountain communities. Existing policy frameworks often fail to adequately recognize the structural constraints faced by these regions, including geographical isolation, limited infrastructure, ecological fragility, and restricted market access. Therefore, a comprehensive and integrated policy approach is required to strengthen livelihoods, improve food systems, and ensure sustainable resource utilization.

First, priority should be given to enhancing household income and local production systems through the promotion of high-value mountain niche products, including fruits, nuts, vegetables, livestock, agroforestry products, and medicinal plants. Integrating these value chains into local and national markets can significantly strengthen rural food systems and improve economic resilience. Equally important is the improvement of agricultural marketing infrastructure, including storage facilities, cold chains, transportation networks, and market linkages to reduce post-harvest losses and improve producers' access to profitable markets.

Effective management of water resources, particularly mountain springs, glacier-fed streams, and hill irrigation systems, should be prioritized to support climate-resilient agriculture. In parallel, investment in research, innovation, and extension services is necessary to advance mountain agriculture, nutrition awareness, child care, and food preparation practices. Special attention should also be given to women's empowerment by improving their access to education, productive resources, financial services, and decision-making opportunities related to household health and nutrition.

At the broader policy level, a multi-stakeholder governance framework involving local communities, civil society organizations, private sector actors, and government institutions should be established to ensure inclusive and sustainable development. The policy framework should further prioritize environmentally sustainable infrastructure development, entrepreneurship promotion, eco-tourism, small-scale industries, and disaster risk reduction mechanisms such as early warning systems, hazard mapping, and community preparedness plans. Preservation of cultural heritage and traditional ecological knowledge must also be integrated into sustainable development strategies. Overall, applied research, evidence-based public policy, and multi-sectoral initiatives are strongly recommended to connect rural producers with urban markets and to optimize the utilization of underexplored eco-resources in Pakistan's mountainous regions.

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