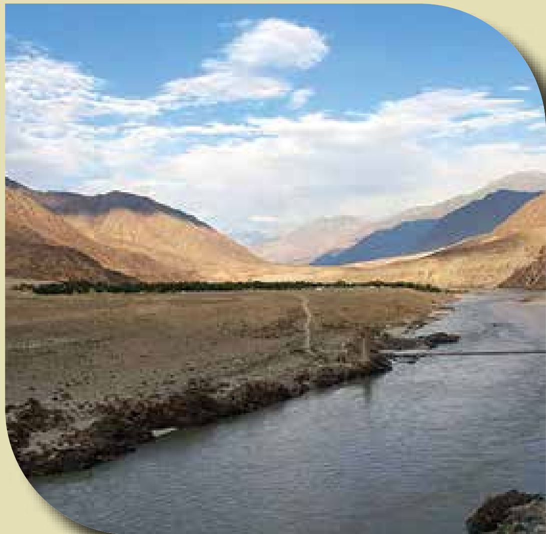
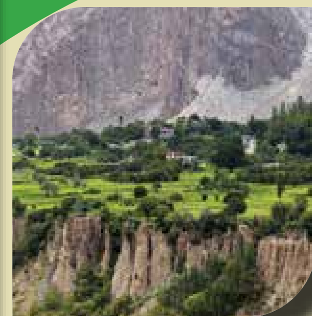
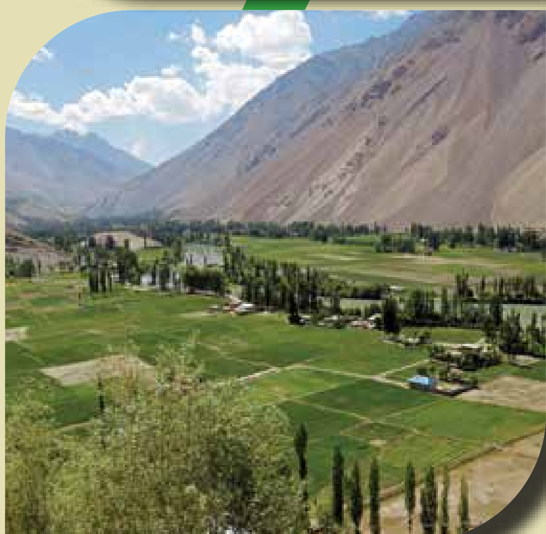
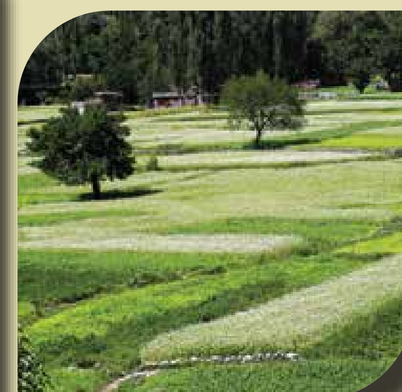
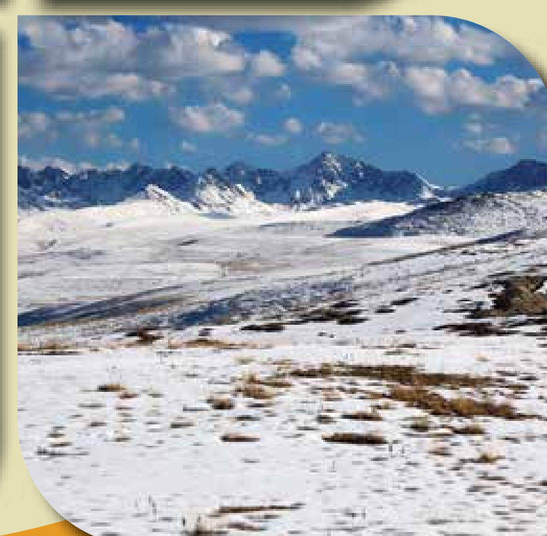
Agro-Ecological Zones and Agriculture Potential of Gilgit-Baltistan





Agriculture, Livestock and Fisheries Department
Government of Gilgit-Baltistan

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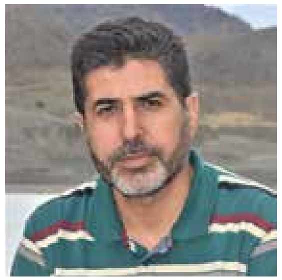

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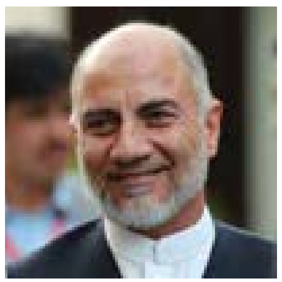

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List of Acronyms

AEZ	Agro Ecological Zones
AFOLU	Agriculture Forestry and Other Land Use
AJK	Azad Jammu & Kashmir
CCA	Climate Change Adaptation
CRU	Climate Research Unit
DEM	Digital Elevation Model
DRR	Disaster Risk Reduction
ET	Evapotranspiration
FAO	Food and Agriculture Organization
FATA	Federally Administered Tribal Area
GB	Gilgit-Baltistan
GDP	Gross Domestic Product
GHG	Green House Gas
GIS	Geographic Information System
GLOF	Glacial Lack Outburst Flood
GoP	Government of Pakistan
GPCC	Global Precipitation Climatology Centre
GPCP	Global Precipitation Climatology Project
KNMI	Royal Netherlands Meteorological Institute
KP	Khyber Pakhtunkhwa
LULC	Land Use and Land Cover
MAE	Mean Annual Potential Evapotranspiration
MAP	Mean Annual Precipitation
NPV	Net Present Value
NWFP	North-West Frontier Province
ORNL	Oak Ridge National Laboratory
PARC	Pakistan Agriculture Research Council
PDMA	Provincial Disaster Management Authority
PET	Potential Evapotranspiration
PMD	Pakistan Metrological Department
SPOT	Satellite for Observation of Earth (Satellite Pour l'Observation de la Terre)
TRMM	Tropical rainfall Measuring Mission
UAP	The University of Agriculture Peshawar
UNEP	United Nations Environment Programme
UNESCO	The United Nations Educational, Scientific and Cultural Organization
USGS	United States Geological Survey (USGS)

Message from

Mr. Muhammad Khalid Khursheed

Chief Minister, Gilgit-Baltistan

"Nations who love and sacrifice for their countries, find the honourable place in history" (Quaid -e- Azam Muhammad Ali Jinnah).

Gilgit Baltistan is very peculiar because of its geography as nature has bestowed with abundant natural resources including water, isolated valleys, long sunny days, cool nights, less precipitation during growing season, diversity in altitude and dry temperate climate. Besides its potential there are certain constraints such as segmented land, small landholding, less technological advancements etc. Despite multiplicity of challenges including food security, remoteness, and frequent natural disasters, the Government of GB is making all efforts to improve socio-economic indicators in the region. Although climate change has become a global phenomenon, GB finds itself in a highly vulnerable position due to its unique topography and fragile mountains prone to floods, landslides and fast melting glaciers. The farming system is also vulnerable to climate change and its impacts. Natural hazards have been increased in GB during the last few years damaging agricultural land, infrastructure and properties of the government and people. I believe that it has now become our fundamental responsibility that the Government of GB shall support its people in improving their resilience by adapting to climate change. The Government of GB is keen to transform such threats into opportunities as more than 90% population of Gilgit-Baltistan is directly or indirectly related to agriculture sector.

My government is committed to bring in concrete reforms in the sector to make the people of Gilgit-Baltistan self-sufficient in agriculture productivity. Food security is a huge threat and challenge which will be talked in the most effective and efficient manner. The sector has been given top priority in resource allocation both in development and non development budget. The portfolio in annual development programme has been increased to manifold, while substantial budget has been provided for immediate needs and interventions in the non development budget. Development of *Agro-ecological Zones and Agriculture Potential of GB (AEZs)* is part of these efforts to pin down key challenges faced by agriculture sector due to climate change and improve productivity of agriculture sector in GB.

I congratulate the Minister, Secretary, and staff of the agriculture department for successfully developing the AEZs for GB. I hope that the agriculture department and others organizations will use information presented in this report to improve productivity of the sector in GB. This will greatly benefit our farming communities as well as the others associated with the sector.

Message from

Mr. Muhammad Kazim Maisam

Minister Agriculture, Government of Gilgit-Baltistan

The Agriculture sector is the backbone of our economy. Rapid population growth and Climate Change are alarming threats to be transformed into opportunities for this sector. The Agriculture Department of GB is striving to uplift the socio-economic condition of GB and to a certain extent has succeeded in transforming agriculture from subsistence to profitability. However, several gaps need to be filled in and the Government of GB is Keen to fill these gaps by establishing partnerships and finding suitable technical solutions befitting climate change considerations in the region.

The growing demand for food requires substantial increase in crop production. For agricultural planners it is of crucial importance to know, how best to optimize crop production on existing cropland keeping in view the challenges involved in production including changing climate. The natural resources, such as land and water, are stressed due to demand for housing and infrastructure to accommodate increasing demand. Therefore, we must produce more from the available resources to feed the ever-increasing population.

The Agro-ecological Zones (AEZ) study of GB was conducted with the aim to guide improved planning in the agriculture sector to increase productivity and harness full potential of the region. It provides basis for a targeted planning and investment in the sector. I am confident that this effort of the Government of GB will equip practitioners in providing vital guidance to the farming community. Depending on how responsibly practitioners act and respond, this will also improve the quality of agriculture extension services in GB.

I am thankful to the Chief Minister GB for providing resources to my department to accomplish this noble task to enhance the knowledge bank for Extension staff, private sector investor, progressive growers, and Planners. This knowledge will facilitate improving the sector, particularly farming community to harness profitable potential of agriculture. I congratulate the Secretary and staff of the Agriculture, Livestock and Fisheries Department for successful completion of this assignment. I have noticed that several experts and staff of the department have contributed to this study, which has increased the credibility of the finding and recommendation provided in this document. I wish visible improvement in extension services and agriculture productivity in GB in the coming years.

Foreword

Mr. Khadim Hussain Saleem

Secretary,
Agriculture, Livestock and Fisheries Department
Government of Gilgit-Baltistan

It is indeed a moment of great satisfaction that the subject study has been successfully accomplished by my department. The need for a systematic and sustainable planning in Agriculture was being felt for long in the wake of recent technological advancement and growing challenges of our time. Agriculture is the backbone of subsistence economy. A complete revamping of the sector is required to transform the current subsistence agricultural economy into commercial economy founded on niche production.

On behalf of my department, I take the opportunity to express my gratitude to the Chief Minister GB and the Minister Agriculture, Livestock & Fisheries Department for taking due cognizance of the situation and providing support at every step, particularly the much-needed financial assistance for this landmark study. This study was a tedious process engaging multidisciplinary contributors and experts. I appreciate all the officers of the department for their valuable inputs to this study. Consolidation and analysis of 100 years data on climate was a huge effort that not only shows dedication of the consultants but also gives great authenticity to the document.

GB faces multifaceted challenges in agriculture sector and the core is lack of data on factors of production and agricultural productivity. Another challenge is competition for limited cultivable land which is becoming scarcer owing to conversion to other uses. The sector needed most updated knowledge on various aspects to improve agricultural productivity which is currently significantly lower when compared to other provinces as well as national averages. This study provides information for strategic planning to identify priority crops and fruits as well as areas suitable for certain crops and not for others. Crop prioritization by specific areas is crucial for optimizing economic returns from the crops farmers grow.

GB's exposure to climate risks is real since it is largely rural with most of economy based on agriculture in mountain areas. This document highlights potential impacts of climate change that need careful consideration in future planning to optimise GB's unique agricultural potential. It is now a responsibility of the practitioners to take maximum benefit of the information provided in this document for the benefit of the agriculture sector and the people of GB.

Executive Summary

Assessment of physical and biological potential of natural resources is important for well-informed decision making and planning a secure future for human population. Global natural resources are reportedly declining fast due to poor management coupled with increased demand by an ever-increasing population and changing climate. Development of efficient and sustainable natural resource use systems, therefore, is needed to feed the growing population. The Agro-Ecological Zones (AEZs) provide comprehensive information on the potential of an area based on combinations of altitudes, soil, landform, and climatic characteristics. This information is useful for developing efficient and sustainable natural resources use systems. It helps explore options and strategies for diversified use of natural resources to exploit growth potential of agriculture in a sustainable manner. Like some other countries in the world, Pakistan also established AEZs in 1980s. Later in 1996, the Food and Agriculture Organization (FAO) developed updated procedure and guidelines to refine AEZs. Based on these guidelines, many developing countries have upgraded AEZs at national and sub-national scales. Recently in Pakistan, Khyber Pakhtunkhwa and Punjab provinces have refined their AEZs.

The methodology used for this assignment took advantage of several datasets including baseline climate data for the period 1960-2020 available from the World Meteorological Organization, Pakistan Meteorological Department, and remote sensing data of LandSat-8 (USGS, 2013) for land use and land cover. Geographic Information System techniques have been applied for the delineation of land use, land use cover (including temporal change).

In 1980, Pakistan was divided into 10 AEZs. Gilgit-Baltistan (GB) and neighboring mountain areas were placed in a single AEZ which was named as Northern dry mountains. Now in this document, GB is divided into seven AEZs, namely: Hot & Cold Temperate zone, Warm & Cold Temperate zone, Transitional Warm & Cold Temperate zone, Cold Temperate zone, Sub Alpine Cold Temperate zone, Alpine Temperate zone and High Alpine & Glacial zone. Boundaries of these seven AEZs are not contiguous and are spread over different administrative units (districts) and geographical regions within districts at different altitudes.

It is important to note that the climate of GB is changing significantly. Some of the climate indicators are alarming for glacial grounds and hydrological balance of the region and the rest of the country. For example, all seasonal, day and night temperatures are increasing. Springs are arriving earlier whereas autumns are arriving later and extending into winters resulting in longer summers and shorter winters. Nights are warming up faster than days. Precipitation is more or less stable, however, a greater concentration is noted during summer as opposed to winter or even distribution during four seasons.

The information related to seven AEZs provided in this document reveals an enormous potential for improved land use and crop diversification in GB. This information will help decision making in agriculture for determining crop suitability on the basis of seasonality and productivity to achieve economic viability as opposed to subsistence. Information provided for AEZs includes characteristics of each zone (e.g., elevation range, temperature, precipitation, current cropping system etc.), climate change trends, agriculture productivity, soil characteristics, land use and land cover, major issues faced in agriculture production and future potential considering climate suitability and economic considerations.

This information compiled for the overall GB region as well as for individual districts is expected to serve as a baseline for future planning and development in agriculture sector in the area.

1. Introduction

There is a mounting pressure on natural resources due to the rapidly growing world population. The growing demand for food requires substantial increase in crop yields either through increasing the area under crops or efficient ways to produce more food from available resources (FAO, 2009; Godfray et al., 2010; FAO, 2017; Kumbhar et al., 2018). For the agriculture planners, it is of critical importance to knowhow best to optimize crop production on existing cropland areas, keeping in view the impact of changing climate (Tilman et al., 2002; Foley et al., 2005).

Yield gap analysis which reveals the difference between crop yield potential and actual yields, provides a quantitative estimate of possible increase in food production capacity for a given location. It is a critical component of strategic food security planning at regional, national and global scales (Lobell et al., 2009). Essential natural resources required for optimal crops yields, such as water and fertile land, are declining both in quantity and quality due to anthropogenic pressures. An additional dynamic is added by climate change, which influences land, water resources as well as temperature, required for food production on sustainable basis. It is, therefore, important to study climate change trends and their specific influences on food production in different geographical regions. Agro Ecological Zones (AEZs) provide information on these and many other aspects of food production and farming systems in general.

This assignment on developing AEZs of Gilgit-Baltistan (GB) was mandated to Wijdan by the Agriculture, Fisheries and Livestock Department, GB. The purpose of this study is to develop befitting AEZs applicable for all the districts and sub districts (tehsils, valleys) of GB to support land-use planning and decision making, especially in agriculture sector. This report also provides district profiles by AEZs, current cropping patterns, and future cropping potentials of various AEZs of GB region.

Apart from using standard guidelines for developing AEZ (see chapter 2 on methodology), the authors have benefited from recent experiences of developing AEZs of Khyber Pakhtunkhwa (KP) province conducted by Helvetas Swiss Intercooperation. Most of the experts who have contributed to this assignment in GB had also contributed to the development of KP AEZs.

1.1. The concept and history of Agro-Ecological Zoning

An Agro Ecological Zone (AEZ) specifies an area characterized by homogeneous ecological conditions for agricultural production. AEZs are systematically useful to compute spatial and temporal data on maximum potential and attainable crop yields. The AEZs can provide wide-ranging familiarity about potential land suitability and productivity, estimation of arable land and land-use planning. AEZ is a core set of application, generated by applying elevation, topography, land cover, soil and climatic characteristics leading to the assessment of land suitability and productive potential. The outputs of AEZs, are commonly the maps showing AEZs and land suitability and quantitative estimates on potential crop areas, yields and production. AEZ, when combined with land use and crop inventories, lead to identification of land utilization types having specific ecological requirements. These delineated zones may thus form the basis for the appraisal of land and associated climate resources. The addition of further information layers on these units (e.g., land tenure, human settlement, crops, livestock infrastructural and water availability, market, and services) may enable further development of advanced application of natural resource planning, management and decision making.

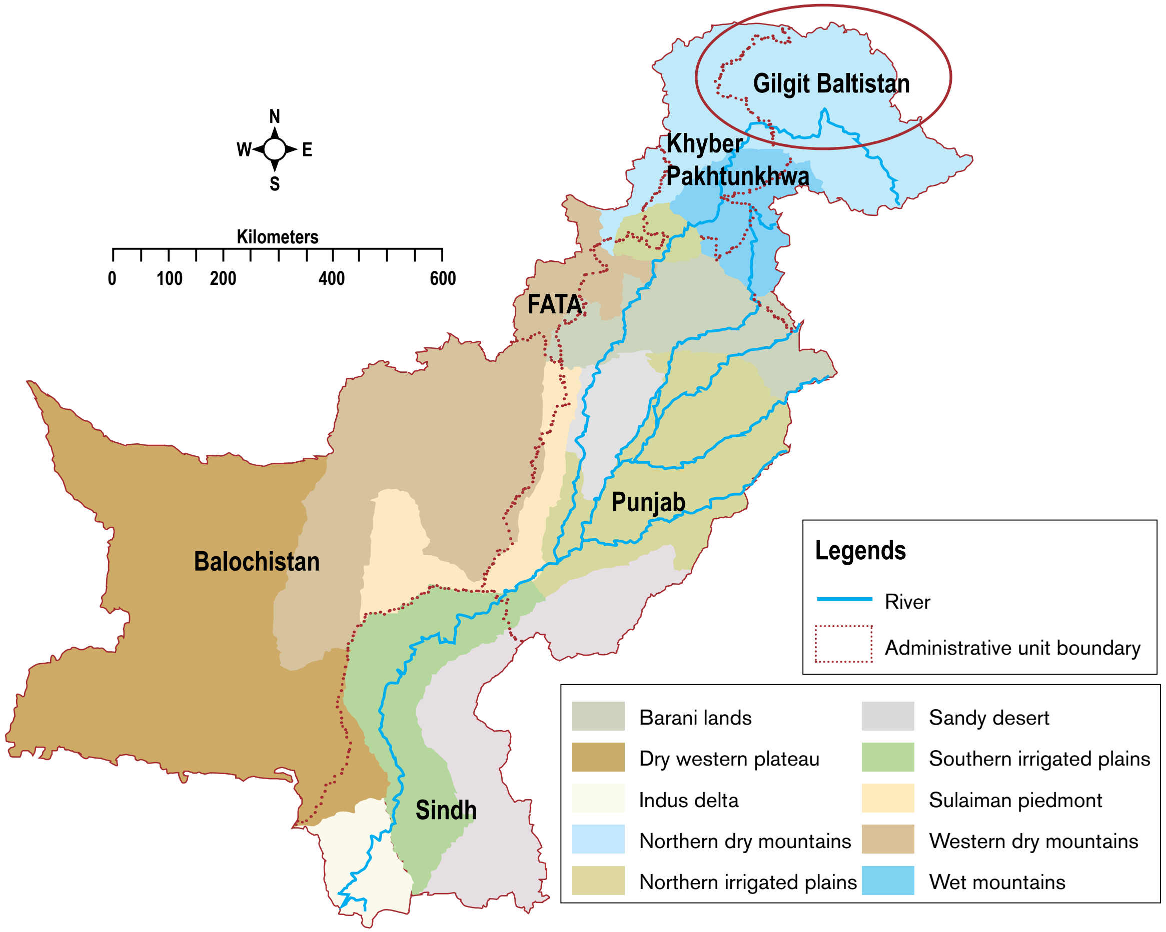
Knowledge of AEZ is considered fundamental to determine appropriate adaptation solutions and long-term sustainability of agricultural and livelihoods systems (Fischer et al., 2002). The AEZ concept involves representation of various components of land and other information, and its visual illustration is facilitated by integration of multiple layers using Geographic Information System (GIS). The combination or overlay of layers produces agro-ecological cells that represent basic land units with specified characteristics. In this way, a land resources database is created containing information on the AEZ cells or individual zones with homogenous conditions.

Pakistan adopted AEZs developed by Pakistan Agriculture Research Council (PARC) in 1980, dividing the country into ten AEZs based on physiography, climate, land use and water availability (**Figure 1**). Similar efforts were made in the neighbouring countries (e.g., Bangladesh and India), where AEZs were defined using similar methodology largely based on landforms, land use and regional climatic parameters. AEZs at that time were defined with limited technological resources and data[1] mainly based on major climatic and altitudinal parameters, resulting in large diverse areas grouped into single AEZs. For example, in 1980, Gilgit Baltistan (GB) and adjoining high mountain areas (e.g., Chitral, Swat, Kohistan, Mansehra) were grouped in a single AEZ (Northern dry mountains), which did not provide local level information on climate and other aspects necessary for understanding suitability of the area for farming. This is the reason that usefulness of AEZ in planning in the agriculture sector was negligible for a vast mountainous region with a lot of diversity.

[1] http://www.fao.org/docrep/007/y5460e/y5460e06.htm. Accessed July 2019

Methodologically, however, zonation introduced in 1980 was novel at that time despite limited technology and climate knowledge. The global AEZ methodology was later refined by FAO in 1996 to enable use of applications at national to sub-national levels based on local conditions (Fischer, 2009). The AEZs developed for GB are inspired by these refined guidelines.

Figure 1: AEZs of Pakistan developed in 1980 by PARC
Source: http://www.fao.org/3/y5460e/y5 460e06.htm. 2022



1.2. Climate change and Agriculture in Pakistan

A significant segment of population (64%) in Pakistan lives in rural areas and earns living from climate sensitive means of livelihoods such as agriculture and livestock (GoP, 2017). Agriculture is climate dependent and will further be impacted by climate change in the future (Hertel et al., 2010; Pimentel et al., 2015). Several studies have identified the effects of climate change on crop yields and have shown that such effects differ across different regions (Tubiello and Fischer, 2006; Nelson et al., 2009; Orlowsky et al., 2016).

Pakistan is ecologically diverse and the 6th most populous country in the world with 2.4% population growth rate (GoP[2], 2017; World Bank, 2018). As a lower middle-income country, the economy of Pakistan is increasingly leading to diversification in terms of production sectors. Agriculture, however, remains a predominant and major economic sector to employ 37% of labour force contributing 23% to the country's GDP. The majority of the country's population depends largely on farming and natural resources. Off-farm livelihoods and employment opportunities are rather limited. Frequent natural hazards in recent years have increased vulnerabilities, particularly of the rural poor. Most small and poor farmers are dependent on subsistence agriculture based on local climate. Their food security is largely at stake due to climate change and variability, especially during the last two decades. It has triggered migration of rural population to urban areas further adding to the environmental problems, overcrowding, and pollution in the cities. About 36% of Pakistani population lives in urban areas and is increasing at 4% per annum (GoP, 2017a). The urban population in GB in 2017 was 16.5%[3], which has increased to 31% in 2021[4].

Pakistan reportedly contributes 0.9% to the world's 36.7 billion metric tons CO_2eq[5] Green House Gas (GHG) emissions (GoP, 2021). Yet it is among the most vulnerable countries to the impacts of climate change (Kreft and Eckstein, 2014; Eckstein, 2018; Eckstein et al., 2021; GoP, 2021). Shifting trends of temperatures and rainfall and more frequent incidents of climate extremes are significantly impacting farming in Pakistan. The rural populations of the country have not exploited an optimal potential of human skills and means of livelihoods to reduce their risks. Impacts of climate change have been felt in the country for the last several years with frequent floods and heat waves (GoP, 2022). The impact of climate change has several extended and deeper linkages at the nexus of food, nutrition, water, energy, affecting livelihoods of people living in rural areas (Fischer, 2009; Nelson et al., 2010; Gyawali, 2015; Campbell, 2018; Galaitsi et al., 2018). These impacts, therefore, are important to understand for devising suitable strategies to transform threats into opportunities based on knowledge about changing climate trends and land suitability. Therefore, climate parameters are extremely crucial for defining characteristics of AEZs so that agricultural systems take climate change dynamics into account.

1.3. Justification for developing AEZs for GB

Several reports have indicated significant shifts in precipitation and temperature regimes in Pakistan (Rasool et al., 2012; Hanif and Ali, 2014; Hanif et al., 2015a, b and c; Hanif, 2017; Nizami et al., 2019). These changes were significant enough to bring planners and scientists to the conclusion that the AEZs known for the last few decades do not hold and need refinement based on current information. This, and voices of several local knowledge holders led to recognize that climatic shifts in GB as elsewhere in the country could also be significant and need to be carefully assessed for developing GB specific AEZs and their potential impact on the farming systems of the area.

The authors of this study were cognizant of the following dynamics while deciding methodology for developing AEZs for GB:

[2]https://www.statista.com/statistics/383256/pakistan-gdp-distribution-across-economic-sectors/
[3]https://portal.pnd.gog.pk/Content/Files/Reports/Gilgit%20Baltistan%20at%20a%20Glance%20New%20Design%202020%20Final_210554160.pdf
[4]https://globaldatalab.org/areadata/profiles/PAKr106/. This report shows the urban population to be 28.5 in 2017 as opposed to the official figure 16.5%.
[5]For a reference: The Energy sector contributes to about 45% of the total national emissions. The Agriculture Forestry and Other Land Use (AFOLU) contribute about 46% emissions; solid waste contributes 4% to the total GHG emissions; industrial processes have a share with 25.76 million tons of CO2 eq. (5%) of the total emissions in Pakistan (Pakistan Nationally Determined Contributions, 2021). Industrial processes are not regulated mainly due to weak law enforcement and compliance monitoring, and lack of overall capacity within public and private sectors.

1. Like in other parts of the world, temperature regime in Pakistan is consistently increasing with significant impact on local climate as felt during the last few years and reported by several studies (cited earlier in this section).
2. Pakistan was placed in the list of top 20 countries vulnerable to climate change (Eckstein et al., 2021).
3. Weather patterns, particularly temperature trends, have changed in GB as witnessed during the recent years. Frequency of extreme weather events has increased over the years.
4. Findings of glacial studies in GB indicated that climate change indicators are notably intense in the mountain areas, which is in sync with other studies that also suggest that mountains are more vulnerable to climate change than plains (Nizami et al., 2020; Nizami et al., 2021).
5. It has been observed that the monsoon rainfall has extended westward up to north-western parts of Pakistan and has penetrated in peripheries of GB[6], resulting in frequent flash floods.
6. Frequent events of GLOFs observed in recent years significantly impact hydrology of the region and seasonal flow of water in rivers affecting crops and agricultural operations.
7. GB is increasingly connected with the market due to improved road infrastructure, digitisation and demand for niche products originating from GB.

Given that these challenges and opportunities are rather significant, and that climate studies indicate shifts in agro-climatic factors, developing GB specific AEZs became urgent and inevitable. No other factor, such as edaphic, altitudinal, or biological, has shown such dynamism as has been shown by the climatic factors.

Farming in the mountain areas has always been a challenge. These regions are highly vulnerable to climate change and environmental degradation (Deb, 2016; Mishra et al., 2016; Salim et al., 2019; Hussain et al., 2021). Members of indigenous communities are keen observers of their natural environment and have developed unique agricultural techniques to maintain and protect the limited available land and water resources. Half of the population in mountainous regions of Pakistan including GB is food insecure (Fahim, 2012). Therefore, improved agricultural production is a matter of quality of nutrition and life.

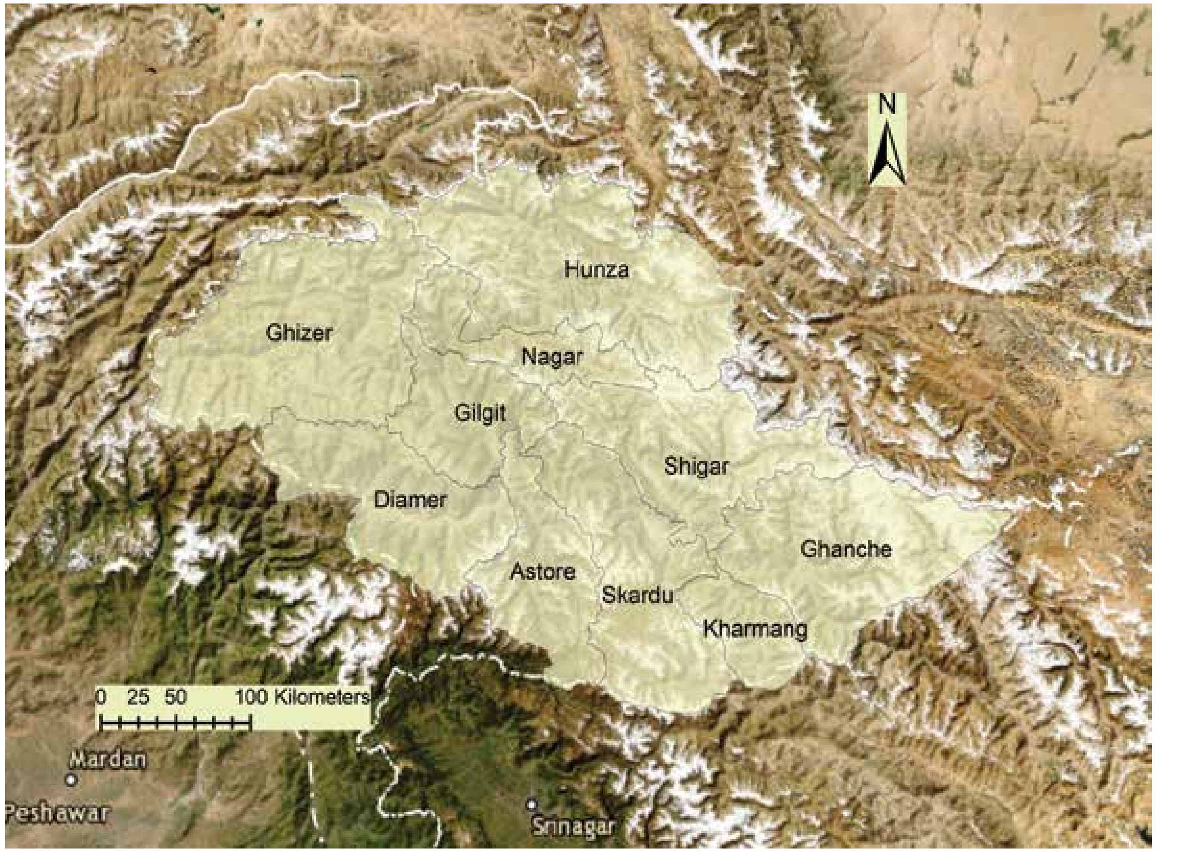
Each district of GB has been described separately in this report with important climatic characteristics and zones. This may help planners to identify most suitable options in agriculture and related fields for the districts and sub-districts. This study thus aims to provide ground for supporting decision making and adapting agricultural practices for improved agricultural production.

1.4. The study area

Gilgit-Baltistan (GB) region is located in the extreme North of the country with predominantly high-altitude terrain and high diversity in terms of altitudinal variation, riverine and glacial ecology. GB is home to some of the world's highest mountain ranges and all five of Pakistan's "eight-thousanders" and more than fifty peaks above 7,000 metres (23,000 ft). Gilgit and Skardu are the two main hubs for expeditions to the mountains. Based on temperature, the area has been divided into three distinct climatic regions, namely, mild, cold, and very cold. Whereas, based on precipitation, it is classified into arid, semi-arid and undifferentiated highlands. **Figure 2** gives district map of GB based on latest shape files provided by the department of Agriculture, Gilgit region.

Figure 2: District map of GB

Source: Based on shape files from Agriculture Department, Gilgit region



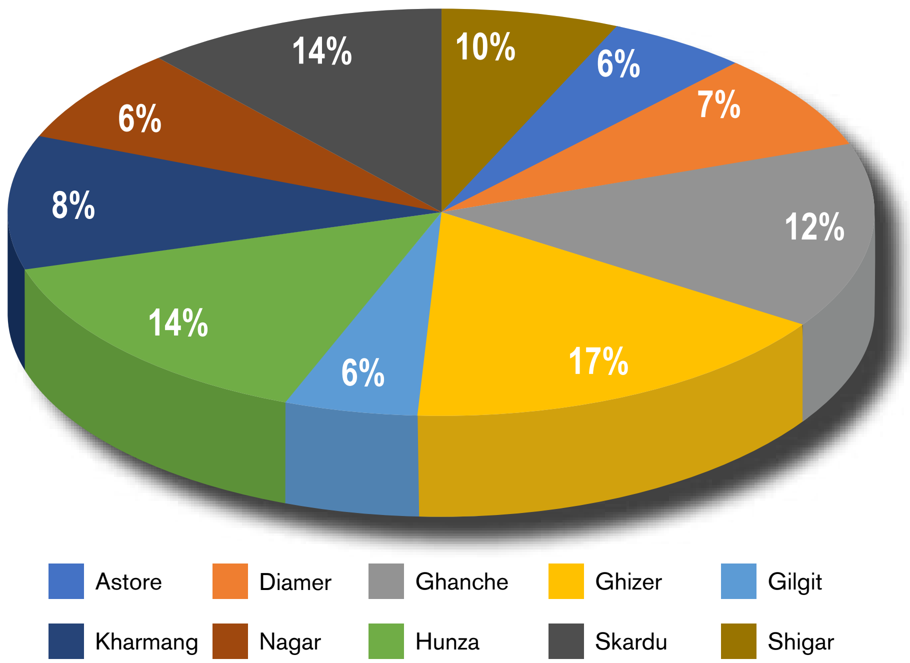
GB comprises three administrative divisions viz. Gilgit, Baltistan and Diamer-Astore and 10 districts namely[7] Astore, Diamer, Ghanche, Gilgit, Ghizer, Hunza, Kharmang, Nagar, Shigar and Skardu, with several tehsils and multiple valleys with distinct features and characteristics. The total population of GB in 2017 was 1,490,000[8], which is projected to have become 1,727,129 in 2022 at a projected growth rate of 3.18%. The study area covers all 10 districts of GB. Table 1 provides area and location of each district whereas **Figure 3** provides percentage area of each district out of the total area of GB.

[6] https://www.thenews.com.pk/print/898709-spatial-shift-in-monsoon
[7] Throughout this document, districts are reported alphabetically for consistency and readers' convenience
[8] Burau of Statistics, Government of Pakistan 2017

Table 1: Location and area (sq km) of districts.

S. No.	District Name	Area (sq km)[9]	Latitude	Longitude
Baltistan Division				
1	Ghanche	8,531	35.1625° N	76.336° E
2	Kharmang	6,144	34.7416° N	76.1592° E
3	Shigar	4,173	35.4765° N	75.6964° E
4	Skardu	10,168	35.3247° N	75.5510° E
Diamer-Astore Division				
1	Astore	5,411	35.3570° N	74.8624° E
2	Diamer	7,234	35.4381° N	73.9360° E
Gilgit Division				
1	Ghizer	12,381	36.2797° N	73.2765° E
2	Gilgit	4,208	35.8819° N	74.4643° E
3	Hunza	10,109	36.3167° N	74.6500° E
4	Nagar	4,137	36.252337° N	74.535871° E
	Total area	**72,496**		

Figure 3: Percentage area of districts in GB



1.4.2 Livelihoods

Farming (crops, horticulture, livestock farming), jobs with public and private sectors, and small businesses are the main sources of livelihoods in GB. There is no vibrant private sector or industry to add value to the agricultural produce to create employment and revenues for the farming population. Most agriculture is for subsistence. The population, therefore, mainly relies on private and public sector jobs within and outside GB to meet cash needs. The government provides subsidized wheat, free basic education, and health facilities in the region. Health and education facilities in the public sector, however, are not adequate. The population spends a lot of resources and time to access these services in other parts of the country located far from GB. Those engaged in small seasonal businesses related to tourism are at risk due to natural calamities and uncertainties of various kinds (e.g., global or national issues influencing travel of tourists to Pakistan and GB). The majority of households cannot afford to purchase preferred and nutritious food, particularly during winters (agriculture lean period), which adds to their vulnerabilities towards malnourishment. Farmers face immense difficulties in procuring quality farm inputs necessary for increasing farm production, which is significantly lower when compared to national averages. These aspects are discussed in detail in later sections of this document.

1.4.3 Agriculture

The agriculture sector holds an important place in GB's economic growth, particularly in ensuring food security and improving nutritional status. Around 90% families are engaged in subsistence farming with per household operational land holding of only 0.48 hectare (four times smaller than in the country) and the per capita land holding of just 0.04 hectare (less than one kanal), which is insufficient to fulfil food requirements of the people (IFAD, 2021). Due to small landholdings and traditional agriculture patterns, farmers are not able to produce enough to feed their families round the year. They cultivate fragmented hilly terraces, and in most of the cases such lands fall under single cropping zones, which limits the ability of high annual crop harvest. In addition, they live with several high-altitude risks, which render their agricultural production exposed to natural disasters and losses. Changing climatic conditions have also impacted agriculture in two ways. One, new opportunities have opened up with warming of the area (temperature rise) and access to market. Farmers' readiness, however, is limited to live up to the new opportunities. And two, farming systems are exposed to natural risks, extreme events, natural disasters, and lack of access to resilient practices to safeguard farmers' investment.

[9]Gilgit-Baltistan at a Glance. 2020. The of Government of GB

With improvement in infrastructure, currently GB is going through a transformation process from subsistence economy to market oriented agricultural development and diversification of agricultural products. Farmers cultivate fragmented hilly terraces with limited crop harvest. In addition, frequent natural calamities further reduce crop productivity and increase dependency on market cereals and subsidized wheat. Being largely a dry temperate zone, GB receives very little monsoon rains. Sole dependence, therefore, is on irrigation. Despite the ample availability of water in the rivers and natural streams, shortage of irrigation water poses another challenge. Constructing irrigation channels in the mountainous terrain is a hard task requiring large investments and thus a limited number of channels irrigate agricultural lands. Farmers lack knowledge of crop options that best suit under these circumstances. Agriculture reportedly has limited production per unity area (discussed in the section below) and the farming families remain inadequately rewarded for their hard work and are undernourished.

The Government of GB has given priority to agriculture sector through allocation of major portion of its limited development funds by initiating several new projects every year with large irrigation infrastructure projects to increase land under cultivation.

It is observed that most pesticide and other agro-chemicals in GB are of low quality and brands. Import and use of low-quality pesticides may have serious environmental and human health implications and affecting biodiversity resources, and agricultural production. The agricultural inputs which include crop protection material, fertilizers, feed, and seeds supplied to the farmers is not quality checked, and not regulated based on their related effects on consumer's health and local crops. GB's policy gap analysis on nutrition (Hussain, 2020) also documented that people in GB often face certain allergies that they are not aware of. Medical practitioners from GB suggest that mountain people need to check themselves for gluten intolerance. Their digestive systems are more adapted to low or no gluten diets such as maize, buckwheat, barley, millet, and potato and not for high gluten foods such as wheat. This makes a direct link between agriculture, health, and the need to develop sustainable production systems taking advantage of improved technology and knowledge regarding climatic conditions of the area.

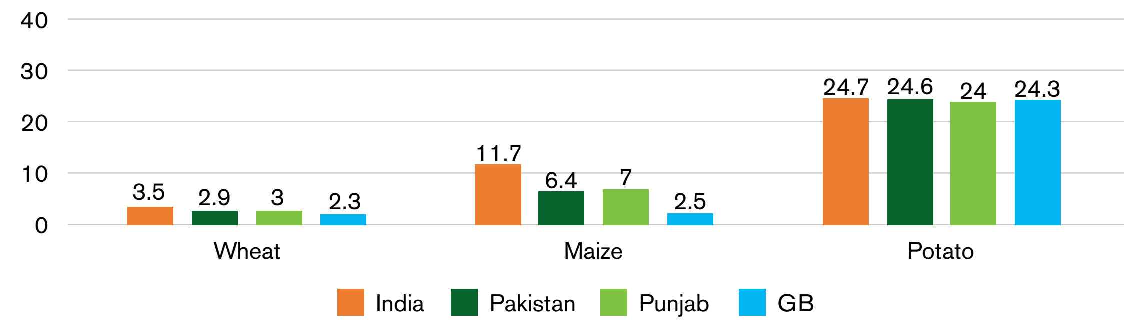
1.4.4 Agriculture productivity of GB

Comparison of per unit area production of wheat, maize (OECD, 2019 quoted in Baig, Ali, & Raza, 2022) and potato[10] for GB with the average production of Pakistan and other countries[11] indicate that agriculture productivity[12] especially for wheat and maize in GB is significantly low. **Figure 4** illustrates this comparison.

1. Wheat in GB performs lowest even when compared to national average, average from Punjab, and India. GB's per unit area yield of wheat is 2.3 metric tonnes per hectare (mt/ha) compared to Punjab province at 3.0 mt/ha[13] and national average of 2.9 mt/ha[14]. India produces 3.5 mt/ha.
2. Performance of maize is also low when compared to Punjab, national average and India. Per unit area yield of maize in GB is 2.5 mt/ha compared to 7.0 mt/ha[15] average of Punjab, national averages of 6.4 mt/ha[16]. India produces 11.7 mt/ha.
3. Yield of potato in GB is significantly at par (24.3 mt/ha) compared to the average of Punjab 24 mt/ha[17], national average of 24.6 mt/ha), and India 24.7 mt/ha[18]. Hence potato despite low performance is doing well when compared to other averages.

This clearly indicates that GB performs well in case of potato and not in wheat production. Performance of potato is good in higher altitudes (2100 meters and higher) areas compared to low altitude areas (below 2100 meters). Maize performs well in lower altitude areas below 2100 meters. Similarly, wheat performs better in lower altitudes but only with varietal improvement. Wheat is also viable in lower altitudes because it does not compete with other crops for land since it is cultivated in winter.

Figure 4. Comparison of major crop yields (mt/ha)



Another important issue is pre-post-harvest losses. GB produces around 169,000 tons of fresh and dry fruits out of which only 10,119 tons (6%) are being marketed in mostly low-end markets and a huge volume equal to 57,178 tons (34%) is wasted due to issues along the value chain (ZTBL, undated). Similarly, in vegetables, against the production of 152,000 tons, around 12,000 tons or more (8%) goes waste due to connectivity problems and lack

[10]Calculated on the basis of primary data taken in 2022 for average production per hectare in Chilas, Gilgit, Astore, Skardu, Shigar (an undated Draft Report of ETIGB project stated potato yield of 15.75MT/ha based on 2009 data)
[11]For wheat see: https://www.atlasbig.com/en-in/countries-by-wheat-production; For Potato see: https://www.atlasbig.com/en-in/countries-by-potato-production; For Maize see https://www.atlasbig.com/en-in/countries-by-maize-production
[12]Productivity refers to yield per hectare
[13]Punjab Agriculture statistics Rabi 2021-22. https://crs-agripunjab.punjab.gov.pk
[14]National Economic Survey report 2021-22.https://www.finance.gov.pk/survey/chapter_22/PES02-AGRICULTURE.pdf
[15]Punjab Agriculture statistics Rabi 2021-22. https://crs-agripunjab.punjab.gov.pk
[16]National Economic Survey report 2021-22. https://www.finance.gov.pk/survey/chapter_22/PES02-AGRICULTURE.pdf
[17]Punjab Agriculture statistics Rabi 2021-22. https://crs-agripunjab.punjab.gov.pk
[18]https://vikaspedia.in

of infrastructure and storage facilities (ibid). Significant losses are also reported for fruits. For example, apricot 35%, apple 17%, grapes 15%, pear 18%, mulberry 56% and walnut 1% (Baig, Ali, and Raza, 2022).

1.4.5 Land tenure

Land in GB is either privately owned or by the Government of GB. The natural forests are government owned with community rights, except in case of Diamer district where forests are owned by the communities. Pastures including the *Khalisa Sarkar* lands are demarcated and are jointly used by the respective communities for grazing, collecting forest products and other natural resources. Farmland in the entire GB is privately owned (except some government owned farms) and mainly farmed by the owners themselves. In Diamer district, however, land is also farmed by tenants. The tenants and the owners share the produce. The tenants also take care of the livestock of the owners, especially during summer when the livestock is taken to the summer pastures.

The private land is owned by the family. However, land distribution is paternalistic and, therefore, family land is inherited mainly by male members of the family. In very few cases, the female members are given their share of land, mainly as per Islamic law of inheritance.

Leasing land is also practiced in few cases in several villages. This is increasing due to migration of male population to the cities. However, there is not a fixed system to share farm produce. This is decided on case-to-case basis as follows:

- Land is leased out for a season on cash. For example, Rs.3000 per kanal[19] (an example from Gilgit)
- Sharing inputs and output on 50:50 ratio (in many districts)
- The tenant provides 40 kg wheat for each kanal of land leased out (example from Shigar) and the straw is taken by the tenant. The tenant is responsible for providing all the inputs
- Grass cutting from irrigated pastureland is given on 50:50 share basis. The owner irrigates the grass land and any other input (mainly protection from free grazing).

1.4.6 Policy environment

The GB Agriculture policy (GoGB, 2018) was approved in 2018, with a core objective of improving food security and increasing agricultural income of rural households through modernization, improving post-harvest management techniques, promoting diversification, and introducing cash crops. This includes consideration for livestock, which is an integral component of farming system and livelihoods, particularly for high altitude communities. Identification of AEZs and agricultural potential are some of the steps being taken to implement this policy by the GB government.

A livestock policy has been developed for GB and is in the approval process. One of the objectives of this policy is to create a food secure GB through legislative reforms, responsive livestock farming, land and pasture resource development, value addition, and strengthening market system. The policy has a strong focus on implementation modalities and there is little on integrating agriculture and livestock farming (and pastures) for a greater farm system return for the farming families.

[19]Around 20 kanals in 1 hectare

Farmers are also aware that the climate change is creating new challenges and they are adapting to these changes using their indigenous knowledge. However, they are not fully equipped to take adaptation decisions adequately suited to new climate patterns to secure crop yields and productivity. It is fundamental to understand the climate trends as well as other factors relevant for agriculture in the area to set well informed adaptation goals. This is not entirely practical without identification of AEZs of the area.

2. Methodology for conducting Agro-ecological zoning

This chapter explains component wise methodology used for developing the AEZs. A schematic diagram of methodological components is given in **Figure 5**. It is important to note that a high weightage has been given to the elevation in determining AEZs since the topographic character plays a critical role in this high-altitude region. Other variables considered for defining AEZs include temperature, precipitation, potential evapotranspiration, land use cover and soil.

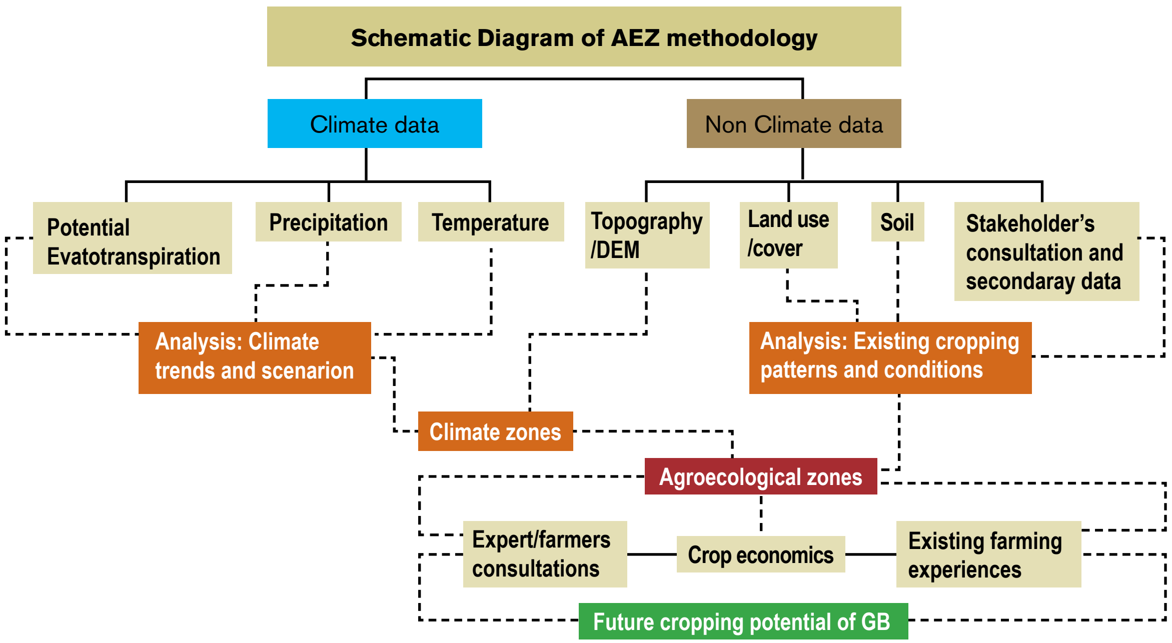
This study benefited from similar work conducted in the region in recent years including AEZs developed for KP by Helvetas Swiss Intercooperation in 2020. Most of the team members conducting this study come from the team which developed the AEZs for KP.

Benefiting from the guidelines developed by FAO (1996), AEZs for GB have been prepared with the most recently available reference data. Updated digital global databases of climatic parameters, topography, soil, and land cover have allowed rich base for developing the AEZs for GB.

Thermal regime of 1901-2020 was used as a baseline for climate assessment. The data sets used in this work are divided into two major groups, namely climate data sets and non-climatic data sets.

Remote-sensing data of LandSat-8 and Geographic Information Systems techniques have been applied for the delineation of land use and land cover (including temporal change).

Figure 5. Schematic diagram of AEZ methodology



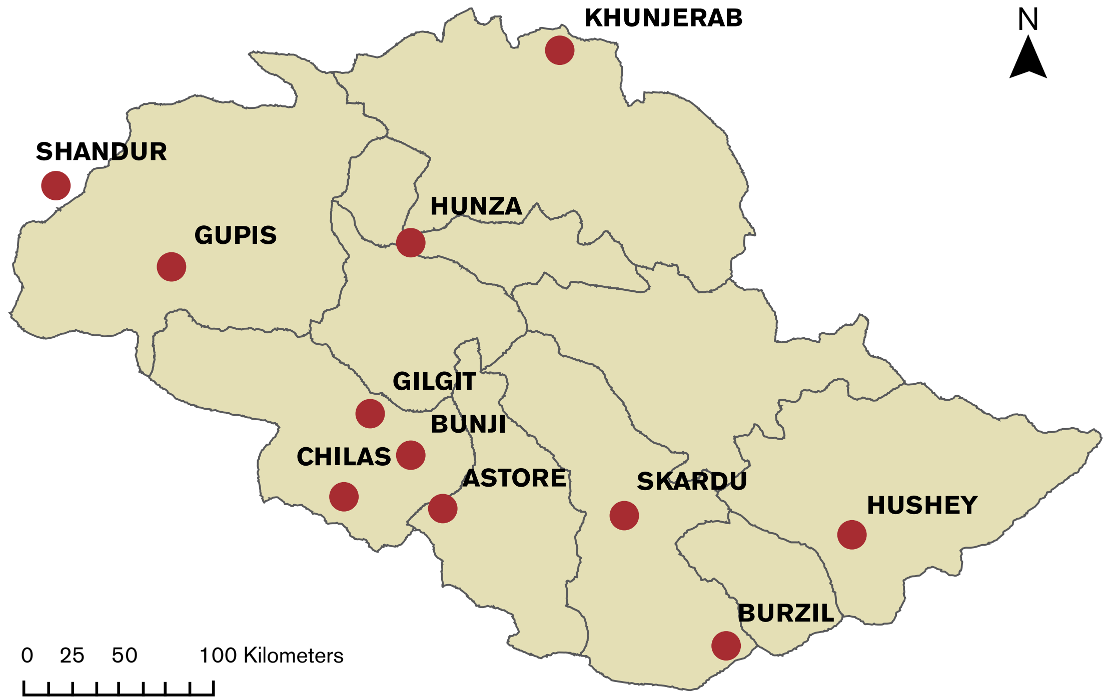
[20]https://www.pmd.gov.pk/en/
[21]http://www.wapda.gov.pk/
[22]https://climexp.knmi.nl/selectfield_obs2.cgi?id=someone@somewhere

2.1 Climate data

For analysis of climate and climate change, the observational data of precipitation and temperature from 1960-2020 were obtained from Pakistan Meteorological Department[20] (PMD) and WAPDA[21] weather stations in GB. The data were available only for those location where meteorological stations are operating across GB (**Figure 6**) and not for individual districts. For climate trends for each district of GB, the data retrieved from global climate database of World Meteorological Organization[22] (WMO) was used.

Figure 6: Locations of meteorological stations in GB

Source: Pakistan Meteorology Department 2021



The team was fortunate to have access to mean monthly minimum and maximum temperatures and mean monthly precipitation data from 1901-2020 from WMO database. This data set was delineated from 1960-2020 for comparison with PMD data of 1960-2020 to discover the degree of discrepancy among the two datasets. These data were further delineated for the last three decades (1991-2020) and the preceding three decades (1960-1990). This was done to find out the intensity in the pace of change during the first, and the second tri-decade. These data were analyzed for monthly, annual and seasonal trends since 1960 and at tri-decadal periods to understand the variations in terms of seasons and when did these variations started increasing. The two datasets from PMD/WAPDA and WMO were compared. It was found that the two datasets showed the same pattern of change during these years. Thus, the degree of confidence for all the assessment results presented in this report is over 90%.

2.2 Climate change scenario – Global and GB

Future global climatic projections are made in relation to GHG emissions scenarios and plausible ways that the world could evolve with respect to carbon sequestration and emissions reduction. These projections are constructed to depict the extent of climate change so that planners can identify pathways to limit the change or consequences that emerge as a result of change. The most recent scenarios used by the United Nation's Intergovernmental Panel on Climate Change (IPCC)[23] for its Fifth Assessment Report (AR5) (IPCC, 2014) are called Representative Concentration Pathways (RCPs). The scenarios were developed by Global Climate Model – Coupled Model Intercomparison Project, Phase 5 (GCM-CMIP5) experiments. This dataset was used in the IPCC Working Group 1 (WG1) Fifth Assessment Report (AR5) Annex I. The same GCM-CMIP5 datasets are used by the Koninklijk Nederlands Meteorologisch Instituut[24] (KNMI) Climate Change Atlas[25], which was utilized to develop near surface mean annual temperature scenarios for GB.

2.3 Topography and elevation

The elevation and slope bands are extracted from a Digital Elevation Model (DEM)[26] from the Shuttle Radar Topography Mission (SRTM)[27] with a resolution of 1 arc second (approximately 30 meter). Due to mountainous terrain of GB, topography and elevation are the most important components of AEZs since these influence temperature and nature of precipitation (e.g., rainfall, snowfall).

2.4 Land Use and Land Cover (LULC)

Geographic Information Systems (GIS) techniques have been applied to integrate remote-sensing data of Landsat for the delineation of Land Use and Land Cover (LULC) (including temporal change) to refine the AEZs. Landsat and/or SPOT products were used upon the requirements of the area and efficacy. Landsat-8 is the most commonly used means for land-use and land-cover studies. In this work, the LANDSAT-8[28] data based on 12 tiles of 30m resolution has been used for LULC analysis. GIS technique has been used for integrating Landsat data for the study area to develop the layers of LULC. High resolution data of summer 2021 season were downloaded by using USGS applications (Global Visualization Viewer at http://glovis.usgs.gov/, USGS 2015) and integrated. The empirical relations were developed and applied to utilize inherent spatial quality of Digital Elevation Model (DEM) in GIS environment for depicting spatial variation in normal monthly and annual mean temperatures as well as annual rainfall conditions in the study area.

2.5 Soil analysis

Two datasets for soil analysis were used.

Soil type determines overall productive potential of a particular AEZ. FAO's world soil database[29] was used for identifying soil type according to the soil parent material data, extracted with one-kilometre spatial resolution.

[23] The IPCC provides regular assessments of the scientific basis of climate change, its impacts and future risks, and options for adaptation and mitigation
[24] Royal Netherlands Meteorological Institute
[25] https://www.knmi.nl/home
[26] https://www.usgs.gov/faqs/what-digital-elevation-model-dem
[27] https://www.usgs.gov/centers/eros/science/usgs-eros-archive-digital-elevation-shuttle-radar-topography-mission-srtm-1
[28] https://www.usgs.gov/landsat-missions/landsat-8 (Landsat 8 is a satellite with a collaboration between NASA and the U.S. Geological Survey, that provides moderate-resolution (15 m–100 m, depending on spectral frequency) measurements and images of the Earth's terrestrial and polar regions).
[29] https://www.fao.org/soils-portal/data-hub/soil-maps-and-databases/en/

This study also used primary data through freshly collected soil samples from **256 locations** in all the 10 districts of GB. The soil samples were collected from farmers' fields. Spatial distribution of soil samples is given in **Figure 7**. The samples collected were analysed for soil texture, organic matter, soil pH, electrical conductivity, and prevalence of basic nutrients (nitrogen, phosphorus, and potassium) and other physical characteristics (Table 2). Based on these indicators, different values were assigned (low-medium-high) to soil types based on credible evaluation references.

Following aspects were considered for collecting the soil samples:

1. Avoid collecting soil sample soon after heavy rain
2. Select an agricultural field which is cultivated at least for the last 15 to 20 years
3. Record GPS coordinates of the field (with mobile phone or GPS device)
4. Collect at least 5 soil samples from an area of 5 square meters in a zigzag format
5. For each of the 5 samples, dig the soil 20 centimetre (6 inches) deep from the top
6. Mix all the soil collected from 6 inches - top to bottom
7. Mix the soil of all 5 samples well.
8. Take 500-gram (1/2 kg) sample from the entire mixed soil. Discard the rest of the soil
9. Pack the 500-gram (1/2 kg) sample in a plastic bag
10. Dispatch the sample to the laboratory for analysis

Figure 7: Locations of soil samples (red dots)

Source: Agriculture department, Gilgit Region

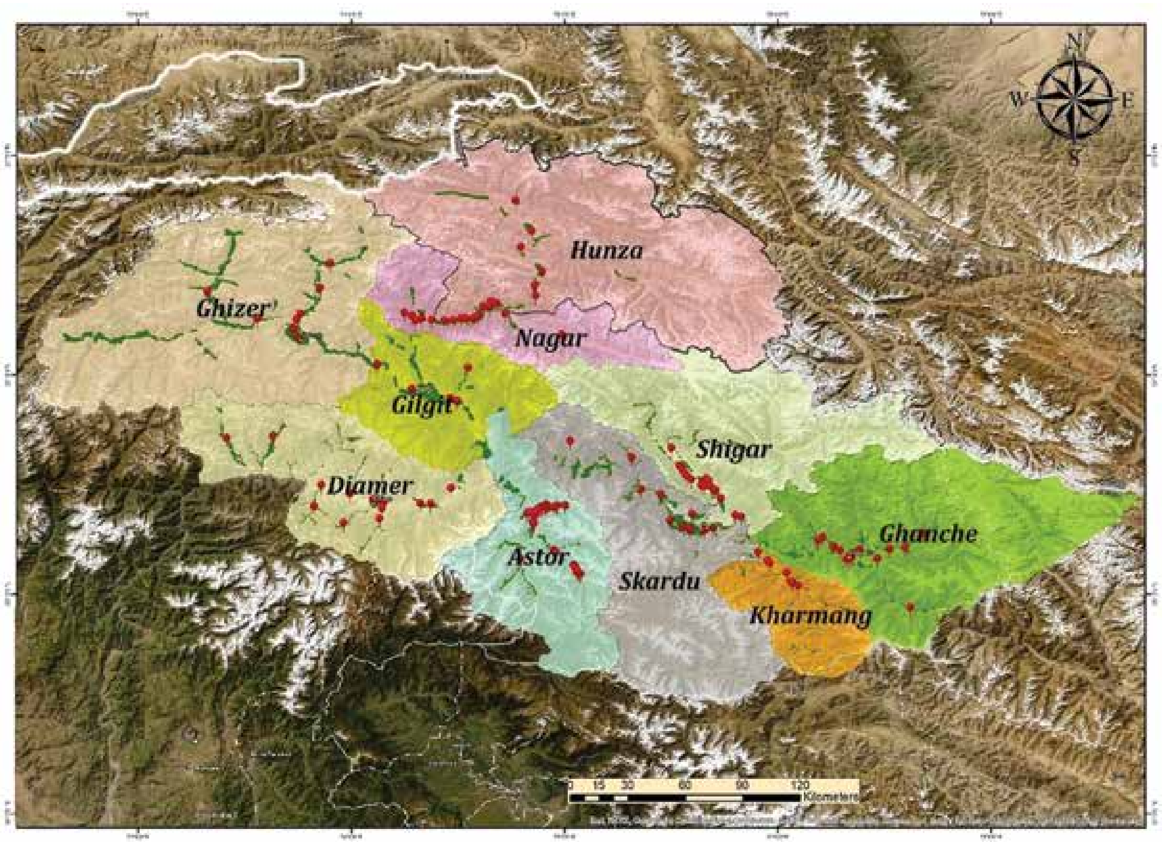


Table 2: Denominations of soil characteristics and evaluation used for soil data analysis

	Characteristics	Range / qualification
1	pH[30]	Soils may have a pH values within a range of 3.5 and 10. Soils can be classified according to their pH value. • 6.5-7.5: Neutral • <6.5: Acidic • >7.5: Alkaline
2	Electrical Conductivity (EC, dS/m)[31]	Soil electrical conductivity (EC) is a measure of the amounts of salts in soil (salinity of soil). It is an excellent indicator of nutrient availability and loss, soil texture, and available water capacity. • Non saline / normal <4 • Saline 4 • Sodic and Saline >4
3	Soil texture[32]	Soil texture (such as loam, sandy loam, or clay) refers to the proportion of sand, silt and clay sized particles that make up the mineral fraction of the soil. For example, light soil refers to a soil high in sand relative to clay, while heavy soils are made up largely of clay. The twelve classifications may include sand, loamy sand, sandy loam, loam, silt loam, silt, sandy clay loam, clay loam, silty clay loam, sandy clay, silty clay, and clay.
4	Organic matter (%)[33]	Soil organic matter is the fraction of the soil that consists of plant or animal tissue in various stages of breakdown (decomposition). Soil organic matter contributes to soil productivity in many ways. Most productive agricultural soils have organic matter between 2-6%. GB's soils have been valued as per following yard stick of organic matter. • Low <1.0% • Medium 1.0 – 2.0% • High >2%
5	Nitrogen (%)[34]	Soil nitrogen supply is a laboratory test that reflects the release of mineral nitrogen from organic matter by soil microorganisms. It is measured in milligrams of nitrogen per kilogram of soil (mg/kg) or percentage and is also known as potentially mineralizable nitrogen. • Low 0.1% • Medium 0.1-0.2% • High >0.2%
6	Phosphorus (mg kg^{-1})[35]	Phosphorus is one of the major plant nutrients in the soil. It is a constituent of plant cells, essential for cell division and development of the growing tip of the plant. For this reason, it is vital for seedlings and young plants. • Low <4 • Medium 4-7 • High >7
7	Potassium (mg kg^{-1}) [36]	Potassium is found in soil solution as the potassium ion, K^+, the form that is taken up by plants. However, the potassium content of fertilisers used in Potassium deficient soils is referred to and measured as 'potash. Sandy soils in high rainfall areas are prone to potassium deficiency. Most heavy soils contain adequate amounts of natural Potassium. • Low <60 • Medium 60-120 • High >120
	Nitrates (NO_3-N)[37]	It is the nitrogen in the nitrate ion and is called nitrate nitrogen and chemically reported as NO3-N. Nitrate is one part nitrogen plus three parts oxygen, so nitrogen only makes up about 22.6 % of the nitrate ion. • Low <11 • Medium 11-20 • High >20

[30] https://www.qld.gov.au/environment/land/management/soil/soil-properties accessed 23.12.22
[31] https://www.qld.gov.au/environment/land/management/soil/soil-properties/sodicity accessed 23.12.22
[32] https://www.qld.gov.au/environment/land/management/soil/soil-properties/texture accessed 23.12.22
[33] Bhatti, 1997
[34] Sillianappa, 1982
[35] Soltanpour, 1985
[36] Sillianappa, 1982
[37] https://www.qld.gov.au/environment/land/management/soil/soil-properties/fertility accessed 23.12.22

2.6 Potential Evapotranspiration (PET)

PET is reflection of the energy available in the atmosphere to evaporate water and to transport water vapor from the ground to the lower atmosphere through winds. It is transfer of water to the atmosphere by evaporating water from the soil and transpiration from plants. Evapotranspiration is a major constituent of hydrological cycle. It varies for different vegetation types under various climatic condition. It is a representation of the environmental demand for evapotranspiration[38]. Relative humidity (RH) is a measure of water vapour content of air. It is the amount of water vapour present in air expressed as a percentage (%RH) of the amount needed to achieve saturation at the same temperature. RH is strongly proportional to temperature and is highly sensitive to temperature changes.

PET data for all the districts of GB was downloaded from WMO for the period 1900 – 2020 and analysed for monthly trends for the tri-decade periods. The findings of this analysis were then validated and projected for 2021 to 2050 by generating time series through KNMI Climate Change Atlas.

2.7 Economic viability of crops - priority crops for various AEZs

Three methods were used to assess the economic viability of crops. 1. Net Present Value 2. An online survey, and 3. Interviews of experts and farmers. These three methods are described below:

1. Net present value (NPV)

NPV comparison was conducted for a few selected crops in different zone. The NPV was calculated with average data figures provided by growers and agricultural experts. This analysis takes into account the total yield of the crops in different zones since various crops perform differently in different zones. Following parameters were used for calculating NPV (**Table 3**).

[38]Ahmad A. et al., (2018). Agro-Ecological Zoning in Punjab - Pakistan. Final Report. Rome, FAO.
[39]5000 square feet / 465 square meters
[40]On 31st December 2022, US Dollar exchange rate to Pak Rupees was 226.

Table 3: Variables for calculating Net Profit Value of selected crops.

A. Cost (per kanal)[39]	B. Revenues (per kanal)
1. Land lease cost (or rental value of land) 2. Land preparation including soil load 3. Seeds cost per kanal 4. Seedling cost (if relevant) 5. Chemical fertilizer 6. Compost /farmyard manure 7. Weeding cost 8. Transplanting cost for input supply (lump sum) 9. Seed sowing operation (lump sum) 10. Application of pesticides, herbicides 11. Crop maintenance cost / daily wage labour 12. Water expenses (including channel maintenance) 13. Harvesting labour additionally engaged 14. Transportation expenses of crop harvest to the immediate selling point near farmgate 15. Fencing cost if relevant 16. Crop storage cost if relevant 17. Packing / packaging cost 18. Miscellaneous expenses	1. Total Yield Kg x approximate price /Kg 2. Total yield (biomass) Kg x approximate value of biomass
A: Total costs (1-18)	**B: Total value of crop per kanal (1 + 2)**
NPV (Pak Rupees)[40]	**B-A**

The most difficult aspect of calculating NPV was transportation costs for acquiring inputs (how far was the market to procure inputs) and transportation cost for trading agricultural products. Another highly variable factor was quality or brand of inputs. Just these two factors introduced large swings in calculated figures from zone to zone and location to location based on terrain and road to farm and farm to market distances.

2. Digital / online survey

In order to prioritise economic viability of crops based on experiences, experts of the agriculture department from across the GB participated in an online survey and provided relevant information. Through this exercise the experts prioritised the most profitable crops for various AEZs. The experts used 1-5 scoring, where score 1 was for least profitable crop and score 5 was for most profitable crop. The experts used geographical areas of the five AEZs to select crops.

3. Interviews

Several farmers and agriculture experts were interviewed to identify priority crops based on their experience regarding environmental factors of various zones and profitability.

Overall prioritisation of crops by zones was conducted based on (i) yield (ii) cost of production (iii) market value of produce (iv) market demand. Interestingly, the results of all these three methods described above were similar to each other and thus confirmed validity of prioritisation. The results are described in Chapter 9.

2.8 Stakeholders' consultations

In addition to the methods and tools described above, parts of data were also collected through a comprehensive consultation process in meetings and workshops with multiple stakeholders. For this purpose, two expert teams undertook three rounds of consultations in all the districts with:

- Staff of district agriculture offices
- Farming communities / cooperatives in randomly selected locations in all the districts
- Representatives of research and academia
- Agriculture development projects based in GB
- Practitioners in agriculture sector with knowledge of GB

In addition to the district workshops, two GB level workshops were held in Gilgit for refining the methodology and data collection. Two other consultations were also held with the staff at the Secretariat and Directorate of Agriculture. Key informants were interviewed online, on phone and through electronic survey portals.

List of people engaged in the consultation process is given at the end of the report.

The following chapters describe Results of this study followed by district chapters, Conclusions and Recommendation.

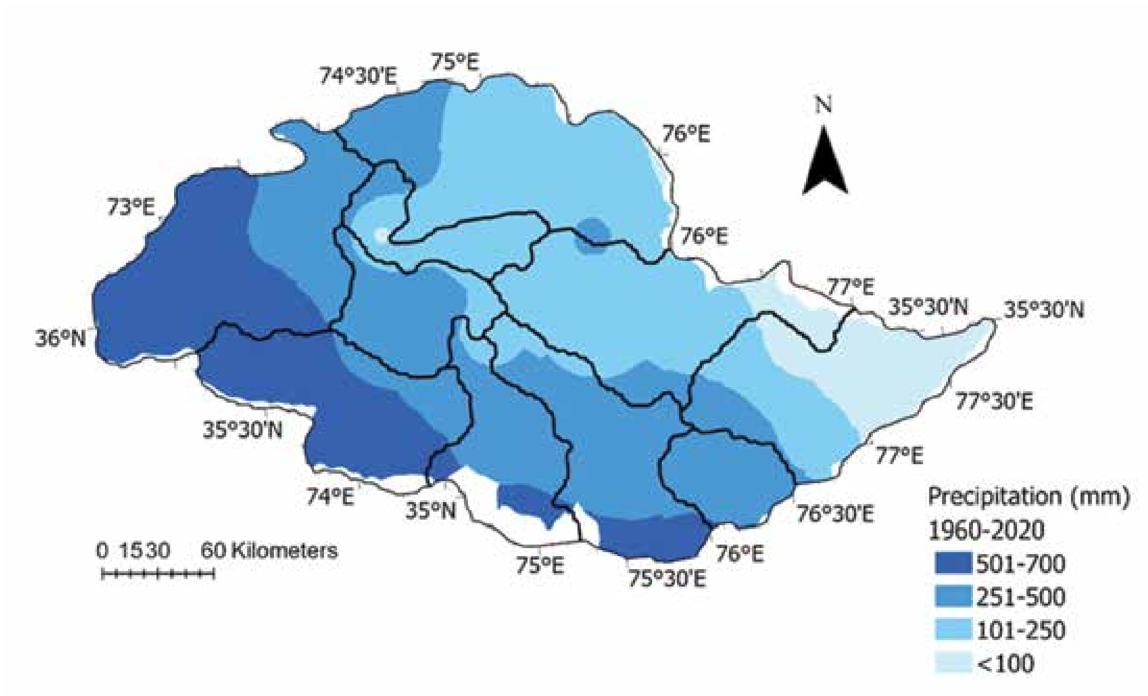

KHARMANG
GHANCHE

3. Climate Change in GB

3.1 Precipitation and temperature

Using temperature and precipitation data of WMO[41], PMD[42], and WAPDA[43], temperature and precipitation trends 1960-2020 were mapped as well as tabulated for seasonal changes for this period.

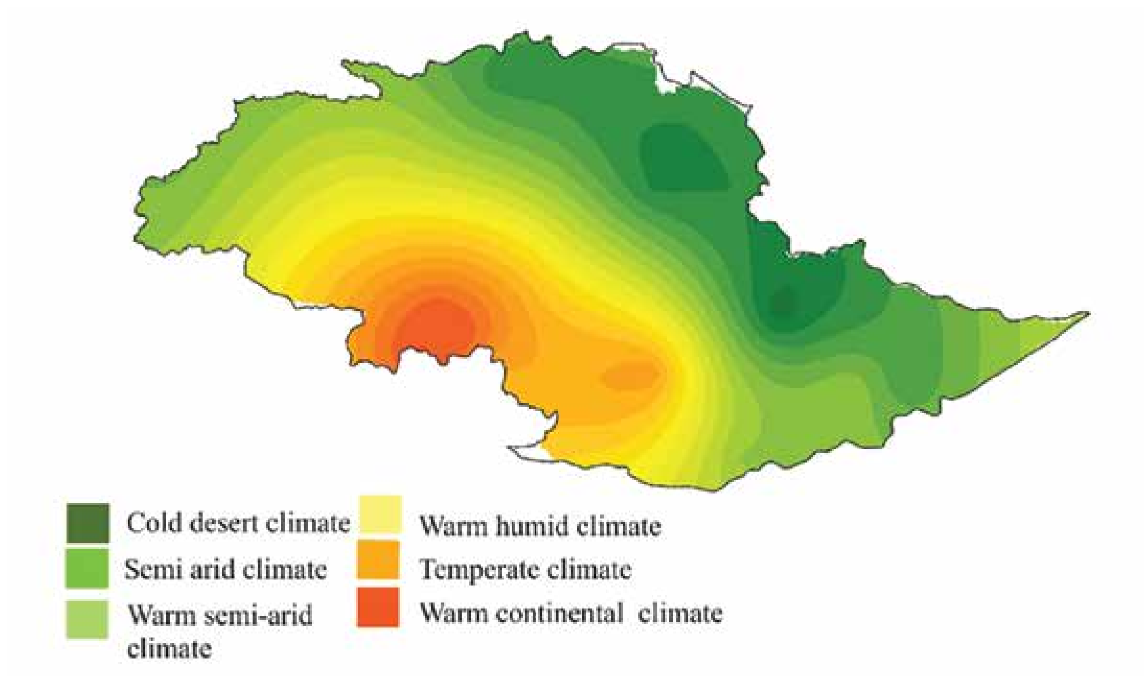
Figure 8: Precipitation trend (1960-2020) for the districts in GB



Precipitation trend for GB (**Figure 8**) shows that the southern parts of the districts Ghizer, Diamer, Astore and Skardu (closer to Khyber Pakhtunkhwa and Kashmir) are wetter than the northern parts.

The climate map of GB developed using temperature and precipitation data since 1960 is given in **Figure 9**. Data used to make climate map and the data in **Figure 8** were used in developing AEZs of GB. The climate map shows that the northern parts of GB are cooler and drier whereas southern areas closer to KP are warmer and relatively humid due to slightly better average precipitation.

Figure 9: Climate map of GB



3.2 Climate change scenarios and trends

Greenhouse Gas Emissions Scenarios:

Greenhouse gas (GHG) emissions are the product of very complex dynamic systems, determined by driving forces such as demographic development, socioeconomic development, and technological change. Because of the complexity, precisely determining their future evolution is not possible. Therefore, scientists develop various scenarios which describe how driving forces may influence future emission outcomes. Scenarios help in climate change analysis including climate modeling and the assessment of impacts, adaptation, and mitigation options for different scenarios. The possibility that one single emissions path described in scenarios will occur, is highly uncertain[44]. The four global GHG emissions scenarios chosen by IPCC[45] to span a wide range of possible climate futures are as follows:

- RCP 8.5 is a business-as-usual scenario with increasing GHG emissions over time, leading to high greenhouse gas concentration levels. RCP 8.5 suggests temperature rise of 3.6 to 4.3^{0}C by end of 21st century.
- RCP 6.0 is a stabilization scenario in which emissions rise quickly up to 2060 and then decrease with a net increase of 3-3.5^{0}C temperature by end of 21st century.
- RCP 4.5 assumes quicker action to limit greenhouse gas emissions with emissions peaking in 2040 and declining strongly until 2080, with net increase of 2.5-3^{0}C temperature by end of 21st century.
- RCP 2.6 describes an all-out effort to limit global warming to below 2^{0}C with emissions decreasing sharply after 2020 and becoming zero from 2080 onwards.

41 https://climexp.knmi.nl/selectfield_obs2.cgi?id=someone@somewhere
42 https://www.pmd.gov.pk/en/
43 http://www.wapda.gov.pk/
44 Summary for Policymakers: Emissions Scenarios. Intergovernmental Panel on Climate Change
45 https://ar5-syr.ipcc.ch/topic_summary.php

Figure 10 presents global temperature projection for 2020-2050 based on ground data from 1960-2020. It may be inferred that gradient of temperature increase in higher towards the north when compared to the south. It is important to note that global trend of higher temperature increase in the north when compared to the south is also true for Pakistan and specifically for GB. In Pakistan, southern parts will see a temperature increase between 0.5 to 1⁰C by 2050 whereas northern and north-western parts of the country will be warmer by 1.5 to 2⁰C by 2050. This is better illustrated in Figures 11 for Shigar as an example, and Figures 12 and 13 for overall GB.

Figure 10: Temperature projection 2020-2050 for Pakistan using Global Temperature projection

Source: extracted from KNMI Climate Change Atlas based on IPCC, 2014 - AR5 CMIP5 subset

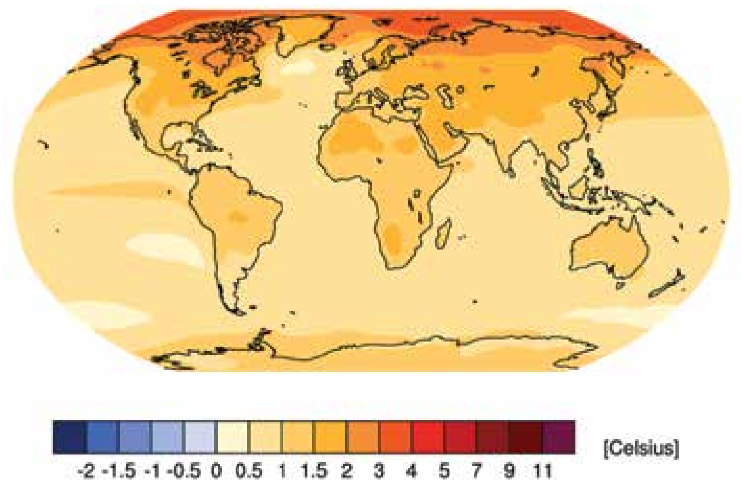
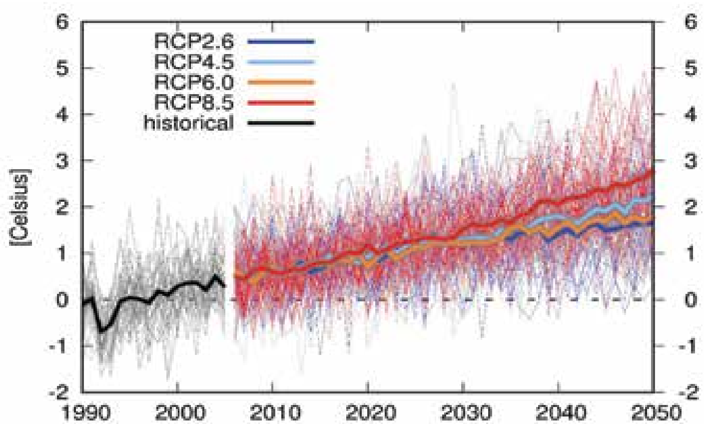


Figure 11: Mean annual temperature time series and projection, district Shigar

Source: KNMI Climate Change Atlas. https://climexp.knmi.nl/plot_atlas_form.py.



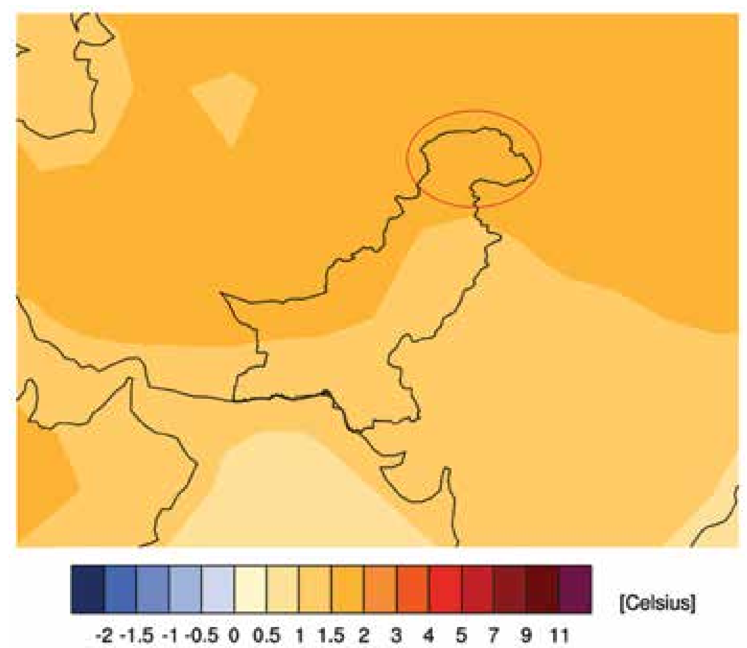
Taking Shigar district as an example, data in **Figure 11** provides trend analysis for each of the four GHG emissions scenarios (RCPs) described above. The time series shows how the temperature change is affected by the emissions control efforts of the world. The sooner the world start controlling GHG emissions, the lesser will be the temperature increase. The Shigar example shows that with the RCP 2.6 (an all-out effort to limit global warming to below 2⁰C), the mean annual temperature of Shigar will still increase by 1.5⁰C while under all other scenarios the mean annual temperature will increase between 2 and 3⁰C by the year 2050. The most likely scenarios for Shigar are RCP 8.5 (business-as-usual) or RCP 6.0 (stabilization scenario) with respect to temperature increase by end of the century.

Temperature Scenario for GB (1990-2050):

Global climate scenarios place GB in the region of projected temperature increase of 1.5⁰C to 2⁰C between 1990 and 2050 under all the climate change projection models (**Figure 12**). This change is drastic when compared to the average temperature change projected for Pakistan in the Nationally Determined Commitments (NDCs) 2021 of Pakistan, which is 0.76 ⁰C (GoP, 2021).

Figure 12: Mean surface temperature projection for GB, 2021-2050

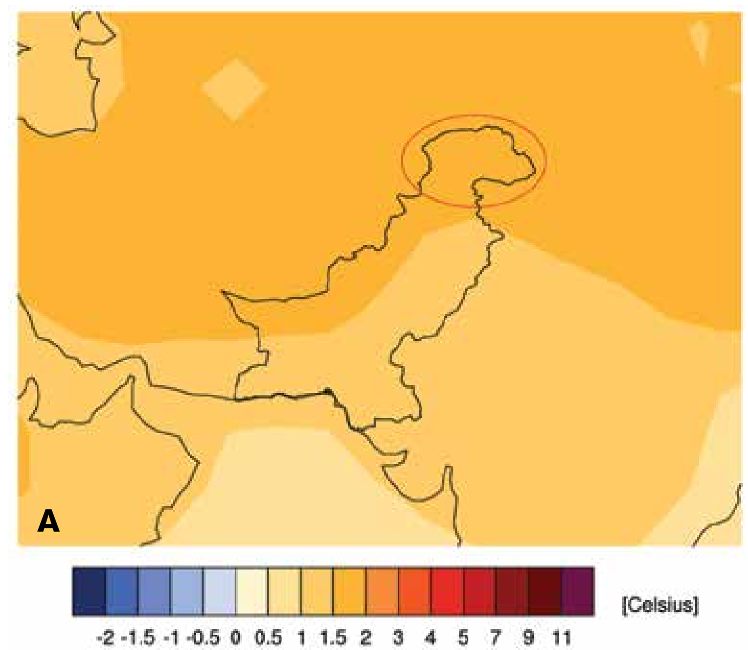
Source: KNMI Climate Change Atlas. https://climexp.knmi.nl/plot_atlas_form.py.

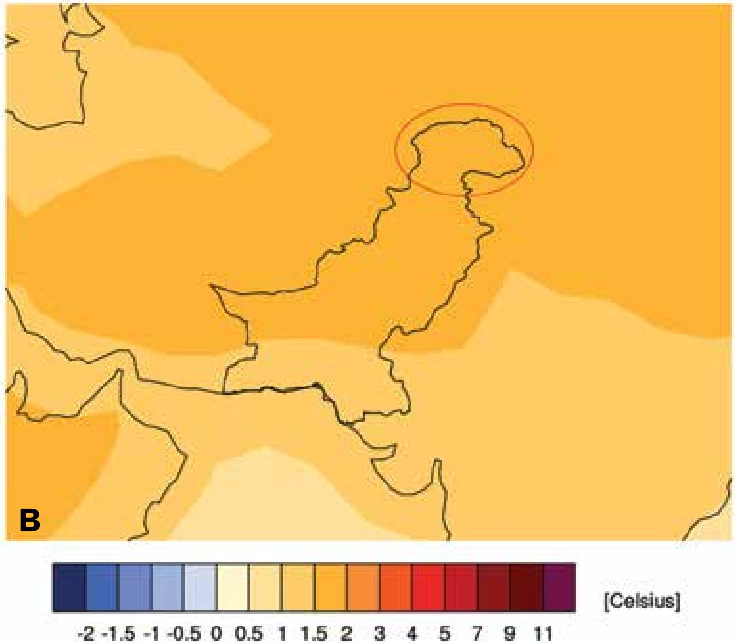


- Both day (maximum) and night (minimum) temperatures in Pakistan are increasing including in GB (**Figures 13**). Days are warming up, whereas night temperatures are warming at a more widespread scale throughout Pakistan including GB. The district wise temperature data analysis indicates that night temperatures in GB are increasing at a higher rate than the days.
- The rate of increase in temperature is higher at higher elevations when compared to lower elevations.
- Analysis of data for seasonal temperature indicates that although the temperature in GB is increasing for all the seasons, spring and autumn seasons are registering higher increase than winters and summers (e.g., increasing up to 2.8⁰C in case of Shigar).
- Due to temperature rise during spring months, the spring is starting earlier and ending earlier or in other words shifting backwards.
- Autumn is setting late and ending later; therefore, summer season is expanding, and winter is getting shorter.

Figure 13 A and **B:** Maximum (A) and minimum (B) temperature projection 2021-2050

Source: KNMI Climate Change Atlas. https://climexp.knmi.nl/plot_atlas_form.py.

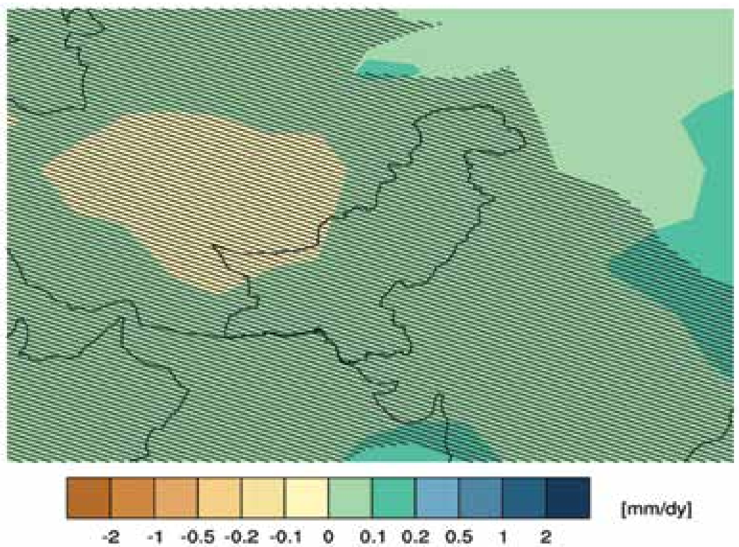




Temperature Scenario for GB (1990-2050):
Precipitation scenario 2021-2050 (**Figure 14**) suggests that precipitation in GB is projected to increase between 0 and 0.1 mm / day like the rest of Pakistan. However, specific shifts in precipitation are observed in the districts. In most districts precipitation is reducing in the winters and spring seasons and increasing during summers and autumns.

Figure 14: Projected precipitation change 2021-2050

Source: KNMI Climate Change Atlas. https://climexp.knmi.nl/plot_atlas_form.py.

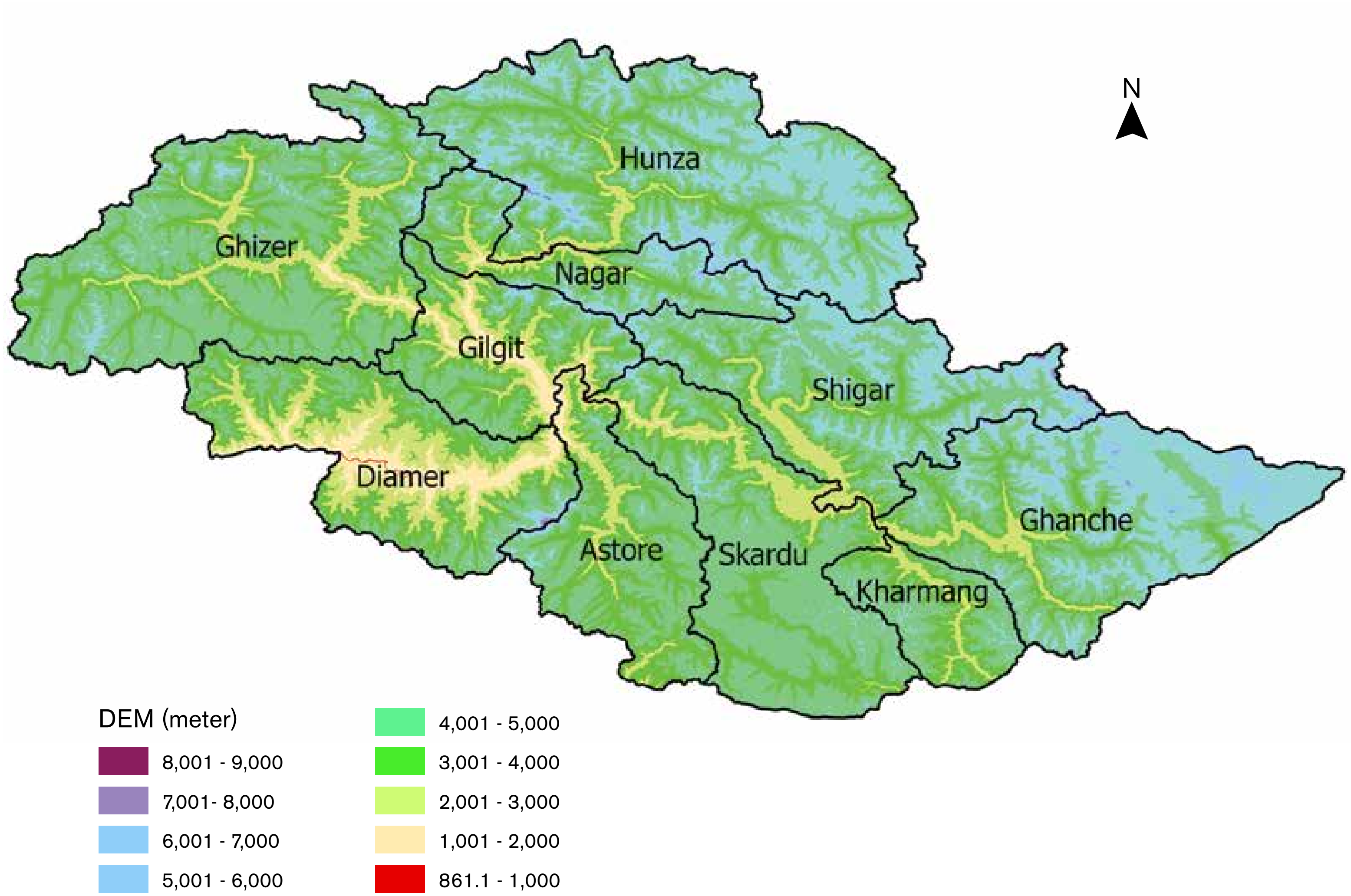


4. Topography and elevation

Topography analysis shows that the entire GB has a hilly / mountainous topography. There is very little prevalence of plains, and that too in small stretches with undulating land conditions that need to be managed for farming. The difference of altitudes is immense from 861 meters to 8,611 meters (Mount K2). This elevation variation prevails in every valley and district, which means that the elevation may be low at valley bottom and higher in the peripheries (**Figure 15**). This kind of topographic variation increases the challenge of agro-ecological zoning and agricultural planning. It is because elevation is likely to change within a stretch of few kilometers and so will the agro-ecological characteristics and cropping patterns.

Figure 15: Digital Elevation Model extracted for GB

Source: https://www.usgs.gov/centers/eros



5. Land Use and Land Cover (LULC)

Land use mapping of GB was conducted using cloud free summer 2021 satellite images and area was determined for each land use (**Figure 16**, **Table 4**). A total area under agricultural land use is reported as 197 Square Kilometre (19,700 square hectares). It is highly likely that some overlaps between agriculture and forest areas were interchangeably reported between the two land uses due to high prevalence of farm forestry in GB. An average difference between this data and data provided by the REDD+ Cell of the GB Forest Department (compiled in 2016) was 2%. **Figure 17** provides graphical distribution of land use data. Further bifurcation of agricultural land uses is given in **Figure 18**.

Figure 16: Land Use Land Cover Map of GB (summer 2021)

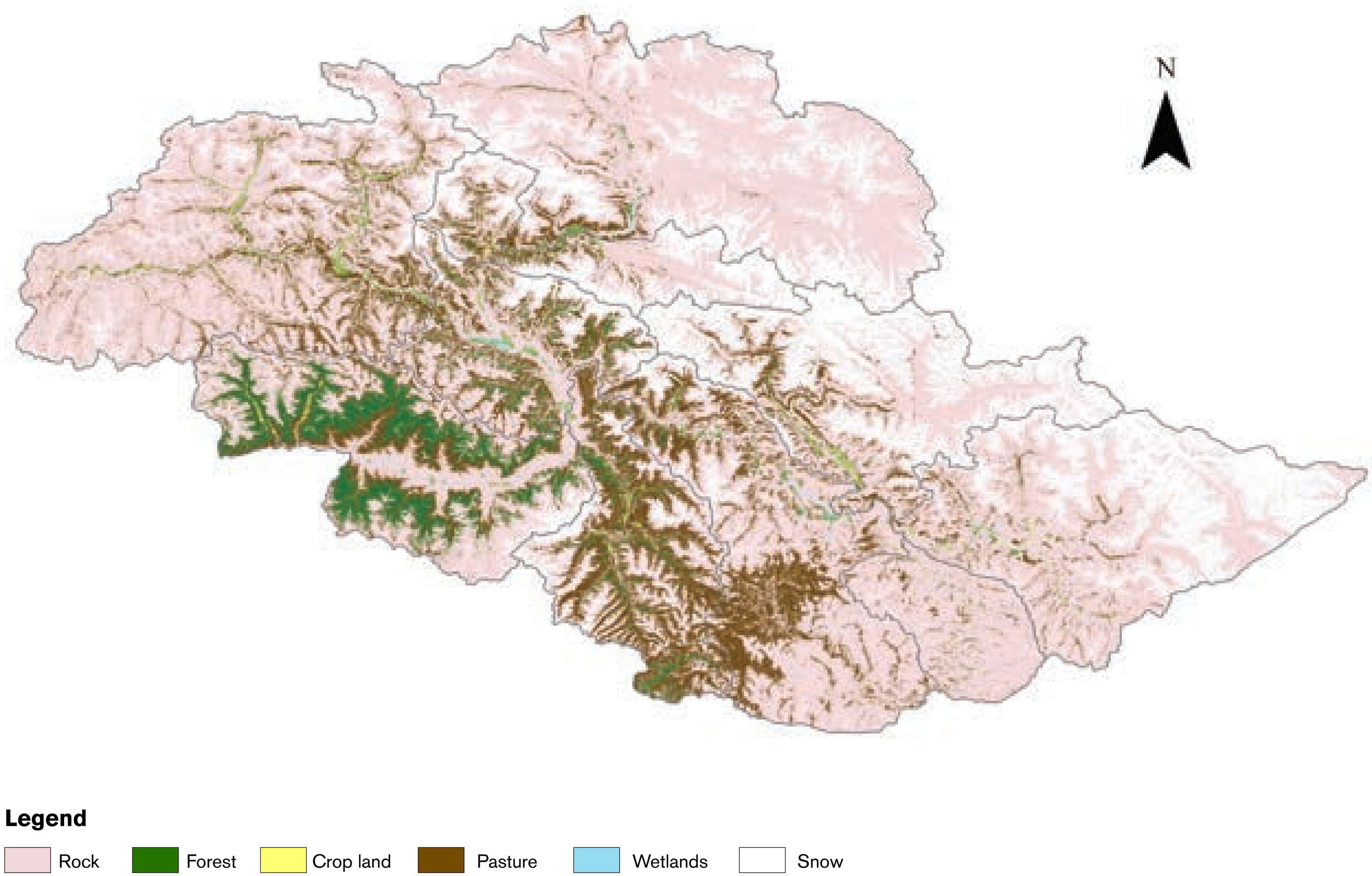


Table 4: Land use data GB 2021.

	Land cover classes	Area		
		Hectares	Sq.km	Percent
1	Agricultural land	91163	911.63	1.3%
2	Forest land	273299	2732.99	3.8%
3	Range Land & Pastures	1737072	17370.72	24.0%
4	Rivers/Lakes	241000	2410	3.3%
5	Built up Area	63523	635.23	0.9%
6	Snow/Glaciers	1608499	16084.99	22.2%
7	Rocks	3024801	30248.01	41.7%
8	Unaccounted for	210241	2102.41	2.9%
	SUM	**7,249,598**	**72495.98**	

Figure 17: Areas under different Land uses in GB in 2021

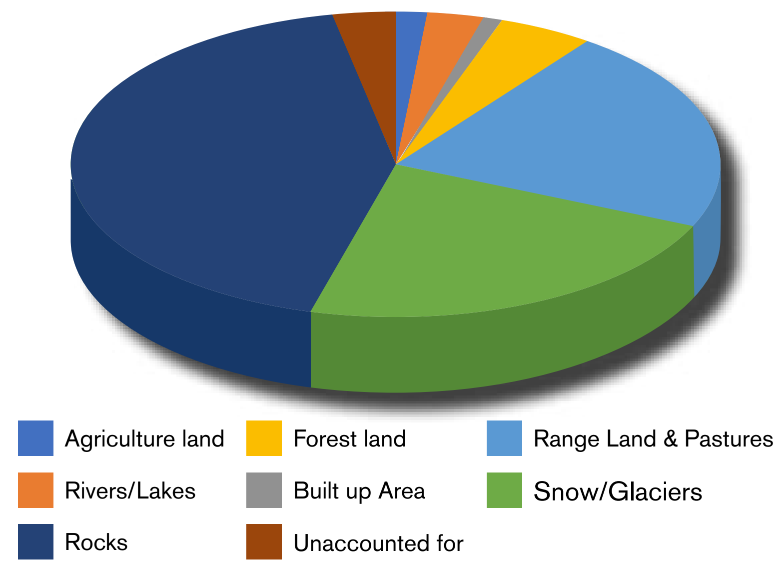
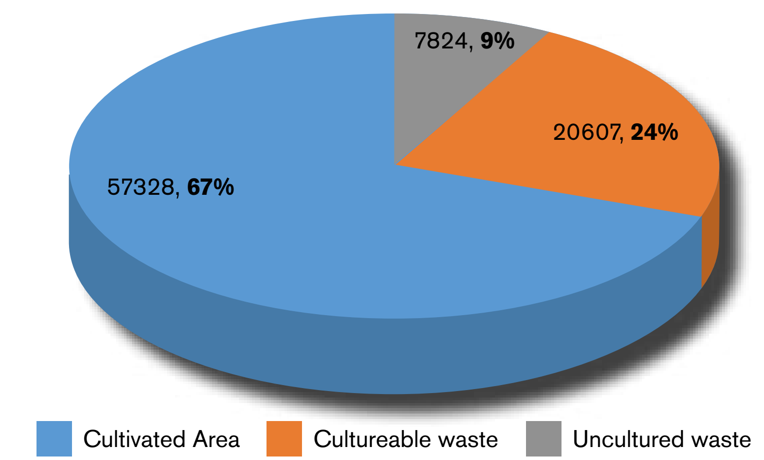


Figure 18: Agriculture land classification in GB (hectares)



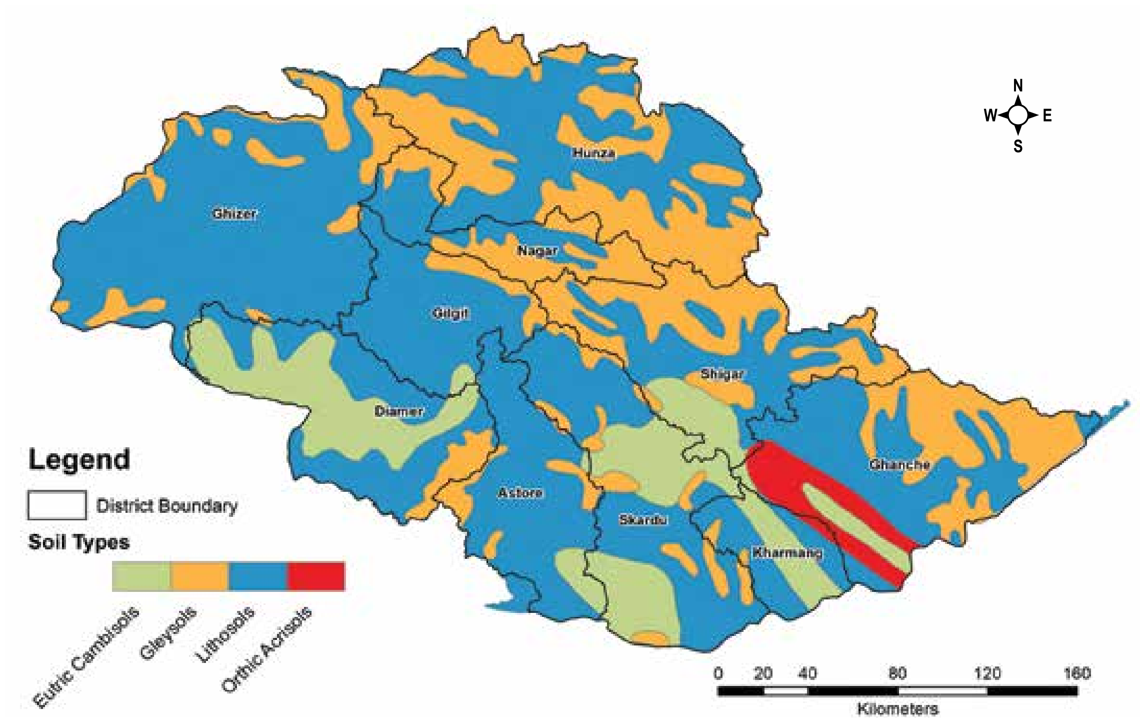
6. Soil analysis

6.1. Soil types of GB

There are several similarities in soil types of different geographical areas of GB due to similar pedogenic processes linked to water-driven erosion and leaching during growing seasons. All four major soil groups are present in GB. These included Lithomorphic, Gleysols, Eutric cambisols and Orthic acrisols. **Figure 19** describes soil type distribution of GB.

Figure 19: Soil type map of GB

Source: https://www.fao.org/soils-portal/data-hub/soil-maps-and-databases/en/



The main soil types in the cultivated land were in the range Lithomorphic, Gleysols, Eutric cambisols and Orthic acrisols. Most soils have **A, B and C horizons**[46]. Horizons are defined in many cases by obvious physical features, mainly colour and texture.

Lithomorphic soils were found as the predominant soil type. Lithomorphic soils do not have a **B horizon**. These soils are less than 30cm deep and consist only of a topsoil over parent material, which may be solid rock or loose sediment. The reason for these soils for being shallow is that they are at a very early stage of formation and the parent materials weather very slowly. Majority of the areas of GB possess coarse-textured lithosols. On rocks, such as limestone and chalk, there is very little residue after solution weathering and thus soil remains shallow. Lithosols are highly prone to land degradation and do not support sustainable crop production if erosion control is not assured. More attention is required for its conservation. If this shallow soil is lost, it will be a long weathering process before new soil is formed. Mountain soils with litho characteristics increasingly face challenges of water erosion, loss of organic matter, nutrient mining, loss of biodiversity, landslides, and soil and water contamination. This affects and reduces productivity and resilience of soils.

Gleysols represent the second extensive soil cover in GB. These soils are found on gentler slopes or in areas of high precipitation where water does not drain away readily and remains locked under snow or glacial covers.

Eutric Cambisol is the third dominant soil type in GB. The Eutric Cambisols in temperate zones are among the most productive soils on earth. These soils though less fertile are used for arable farming and as grazing land. Cambisols on steep slopes are best kept under forest; this is particularly true for Cambisols in highlands.

Orthic Acrisols is found in a small U-shaped patch of Ghanche only. Acrisols are formed on old landscapes that have an undulating topography. The age, mineralogy, and extensive leaching of these soils have led to low levels of plant nutrients, excess alluvium, and high erodibility, all of which make agriculture problematic. Orthic acrisols are deep, well drained, dark brown loamy soils in the A horizons and to some extent B horizons. Roots are mainly confined to the topsoil. The pH is neutral in the A and B1 and becomes strongly acidic deeper in the solum.

6.2. Soil physico-chemical properties

Soil types have different physico-chemical properties, which may have a great impact on aeration, permeability and fertility retention, and lead to differences in the ability to store and supply nutrients which inevitably affects soil organic matter and pH concentrations.

Generally, the soil in GB was fine to coarse in texture ranging from Sandy loam > Silty clay loam > Silt loam in all 10 districts and slightly acidic to slightly alkaline in nature, containing considerable amount of calcium carbonate contributing towards the neutral pH in majority of districts.

Very low organic matter content was found in most of the samples. An appreciable amount of organic matter was found in soil samples collected from Astore, Diamer, Hunza, Shigar and Nagar Districts. The amount of organic matter was in marginal level for Skardu, Kharmang, Ghizer, Ghanche and Gilgit Districts. It was observed that the silty clay loam texture was a dominant type particularly in Skardu, Kharmang, Nagar and Shigar Districts.

Lithomorphic are thin soil types where the parent rock is dominant feature in soil development. The best known lithomorphic soils are calcimorphic, which develop on calcareous substrates (chalk or limestone). The soil is dark brown in colour and is generally alkaline, 7.5 to 8.5 pH. The results also revealed that the pH ranges for districts with lithomorphic features is neutral to slightly alkaline range and hence approves its calcareous substrates having lithomorphic qualities where most of the soils were based on the predominant composition of loam soils (sandy or silty loam). The districts include Nagar, Skardu and Shigar.

[46] A soil horizon is a layer parallel to the soil surface whose physical, chemical, and biological characteristics differ from the layers above and beneath. https://en.wikipedia.org/wiki/Soil_horizon accessed 03.01.23

Sandy loam mainly found in the areas of Astore, Hunza and Ghanche where the parent material contributed to this type of texture in Astore and Hunza and were mostly lying on Lithomorphic soils followed by a small portion as Gleysols. Moreover, Ghanche falls in the area where the major localities are laid on lithosols but also other three types of parent material. Careful management of these soil types is needed to ensure drains are maintained and to prevent pugging and compaction especially by livestock activities, during wet periods. Silty loam was the predominant soil texture found also in Ghizer with the major class of Lithomorphic soils occupied the district.

Skardu generally seems to have low organic matter and low N-NO_3 (<11), P (<4), and K (<60) except in case of perennial nursery grounds, forests, and captivated farms. This is further worsened by low N and P incorporation in all districts of the sampled soils. An NPK ratio of 4:2:1 (N: P_2O_5: K_2O) is generally considered ideal and accepted. However, the NPK ratio in this area seems drastically low. The efficiency of even balanced NPK fertilization may have remained low due to the wide-spread deficiencies of secondary micronutrients. In Astore, Ghizer, Gilgit and Hunza, it seems that K is marginally to adequately enough but still requires proper management for agriculture production.

Stringent measures should be taken to protect the fertility of cultivated land during agricultural management; Nitrogen and Phosphorus deficient soils coupled with global warming pose a serious challenge to the conservation of organic matter (OM) and nutrients in this region. Furthermore, area specific detailed assessments may help in identifying the factors that influence the variation of OM and pH while also quantifying their explanatory powers to provide theoretical evidence for the development of strategies for soil nutrient management. **Table 5** summarises soil type and characteristics.

Table 5. Organic matter, fertility, texture, pH, and soil type.

District	OM%	Fertility			Texture					pH	Soil type
		NO3-N (mg kg^{-1})	P (mg kg^{-1})	K (mg kg^{-1})	Silt loam	Sandy loam	Clay loam + loam	Silty clay loam	Dominant texture		
Astore	Adequate	Low	Low	Adequate	20%	80%	0	0	Sandy loam	Slightly acidic to neutral below 2135 meters Neutral to slightly alkaline above 2135 meters	Lithosols 90% Gleysols 10%
Diamer	Adequate	Low	Low	Low	40%	0	0	60%	Silty clay loam to silt loam	Neutral to slightly Alkaline above 2135 meters Slightly Acidic-neutral below 2135 meters	Lithosols 40% Cambisols 50% Gleysols 10%
Ghanche	Marginal	Low	Low	Low	10%	90%	0	0	Sandy loam	Slightly Acidic-neutral in Keris, Ghwari, Barah Neutral to slightly alkaline in the rest of Ghanche	Lithosols 45% Gleysols 35% Orthic acrisols 15% Cambisols 5%
Ghizer	Marginal	Low	Low	Adequate	50%	-0	30%	20%	Silt loam to clay laom and silty clay loam	Neutral to Alkaline in most of the district. Slightly Acidic to neutral in few areas closer to Chitral.	Lithosols 90% Gleysols 10%
Gilgit	Marginal	Low	Low	Marginal	10%	0	0	90%	Silty clay loam	Neutral to slightly alkaline in most of the district. Slightly Acidic to neutral in few areas adjoining Astore / Diamer.	Lithosols 90% Gleysols 10%
Hunza	Adequate	Low	low	Marginal to Adequate	25%	50%	0	25%	Sandy loam to silty clay loam and silt loam	Slightly alkaline	Lithosols 50% Gleysols 50%
Khar-mang	Marginal	Low	Low	Low	25%	45%	30%	0	Sandy loam to loam and silty loam	Neutral	Lithosols 60% Cambisols 30% Gleysols 10%
Nagar	Adequate	Low	Low	Low	0	25%	25% (loam)	50%	Silty clay loam to loam and sandy loam	Slightly alkaline	Gleysols 60% Lithosols 40%
Shigar	Adequate	Low	Low	Low	10%	25%	0	65%	Silty clay loam to sandy loam	Neutral to slightly Alkaline	Lithosols 45% Gleysols 40% Cambisols 15%
Skardu	Marginal	Low	Low	Low	14 %	21%	0	65%	Silty clay loam to sandy loam	Slightly Acidic-Neutral in areas adjoining Ghanche. Neutral to alkaline in the rest of Skardu	Lithosols 60% Cambisols 30% Gleysols 10%

7. Potential Evapo-Transpiration

Normally, due to increase in temperature, evapotranspiration rate becomes higher, consequently most of water is transferred to the atmosphere. However, despite temperature increase noted in most of the districts in GB, average evapotranspiration is not dramatically increasing. Average relative humidity shows a slight decreasing trend in the districts owing to increase in temperatures and aridity factors. KNMI time series using all four emission scenarios for the districts where hot conditions are more pronounced during cultivation season (Astore, Diamer, Ghizer and Gilgit) against the historical data since 1900 show stability in Potential Evapo-Transpiration (PET) till 2050 (**Figure 20 to 27**). This analysis suggests that most of GB experiences low actual evapotranspiration, especially in the mountain areas with some vegetation (Astore/ Diamer and parts of Gilgit and Ghizer shown in **Figures 22-25**). Crops in most of the GB require regular irrigations at different stages of growth due to aridity and inadequate rainfall during growing season. A higher degree of evapotranspiration may also increase plant-water requirement during hot season.

Figure 20: Projections of PET for Astore under all emissions scenarios

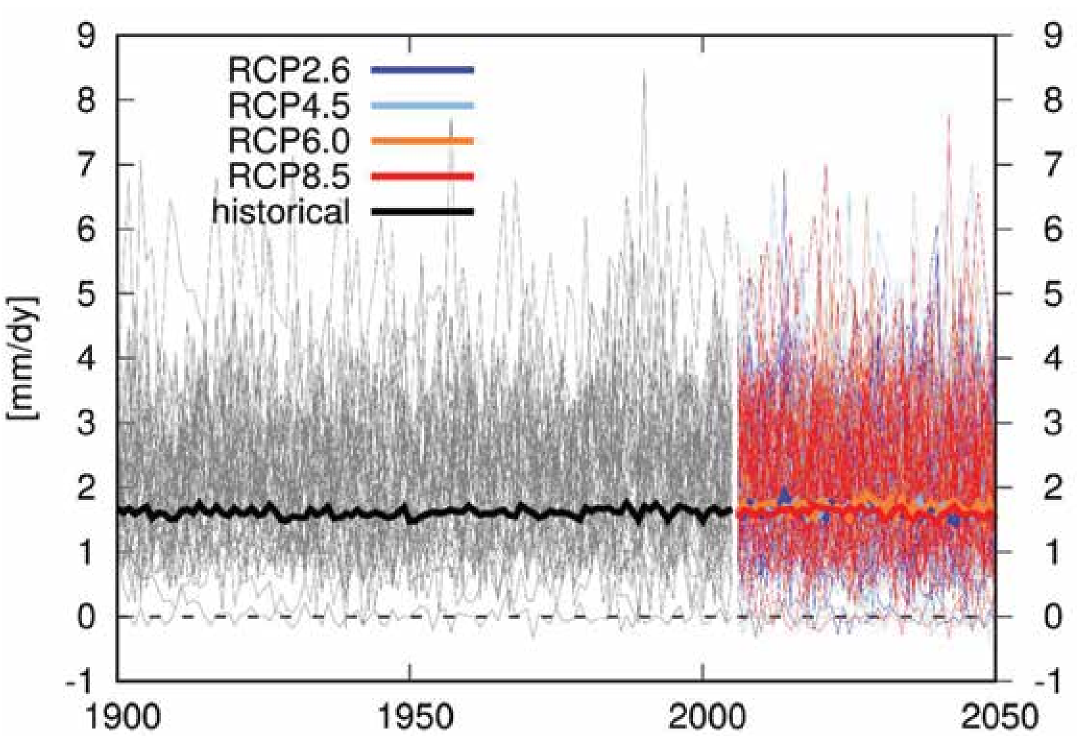


Figure 21: Projections of Relative Humidity for Astore under all emissions scenarios

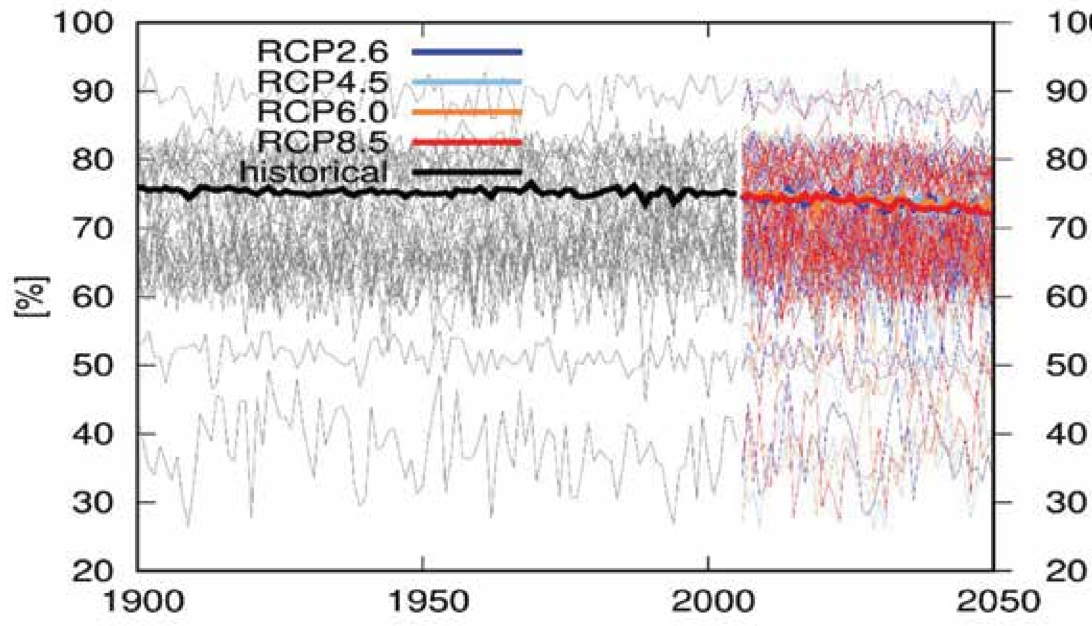


Figure 22: Projections of PET for Diamer under all emissions scenarios

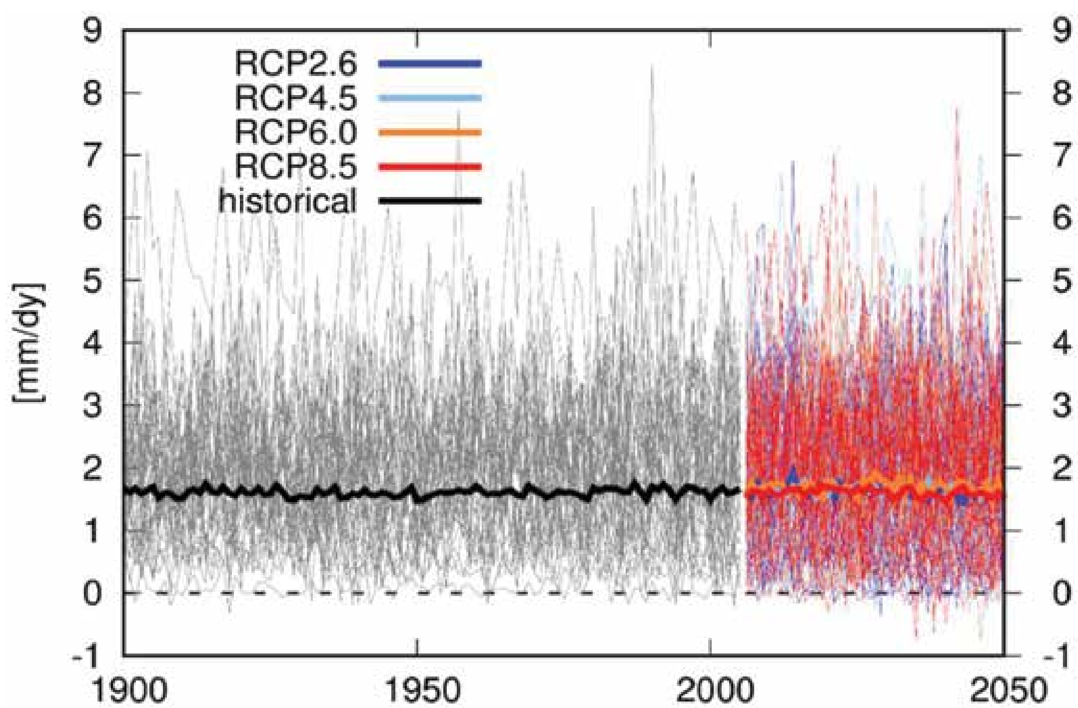


Figure 23: Projections of Relative Humidity for Diamer under all emissions scenarios

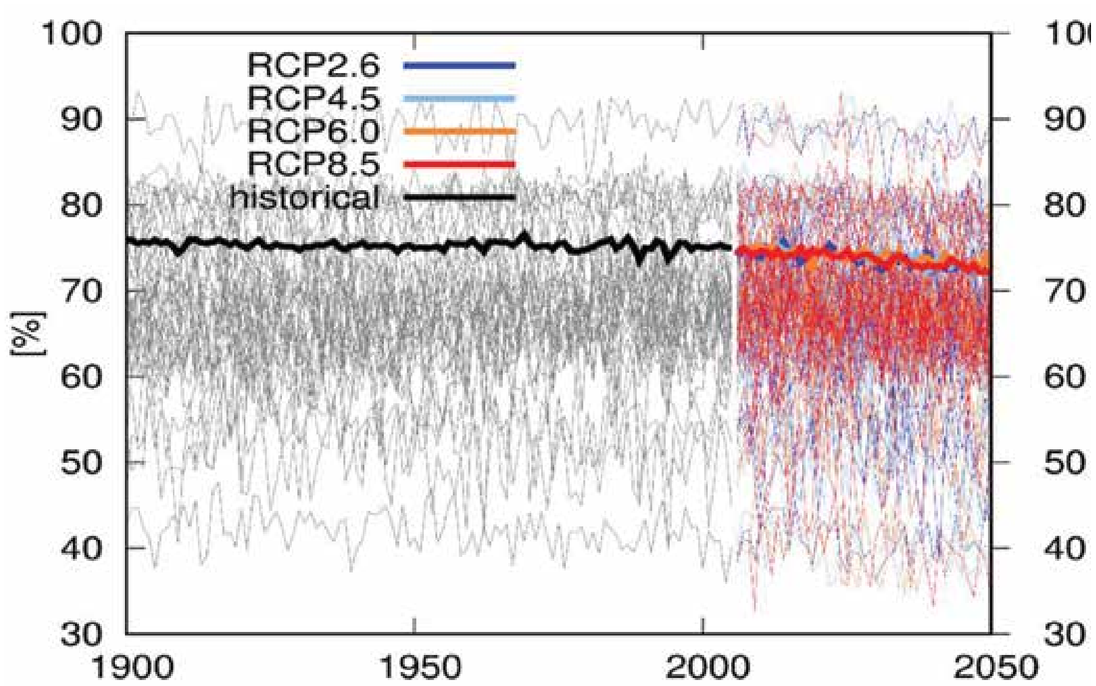


Figure 25: Projections of Relative Humidity for Gilgit under all emissions scenarios

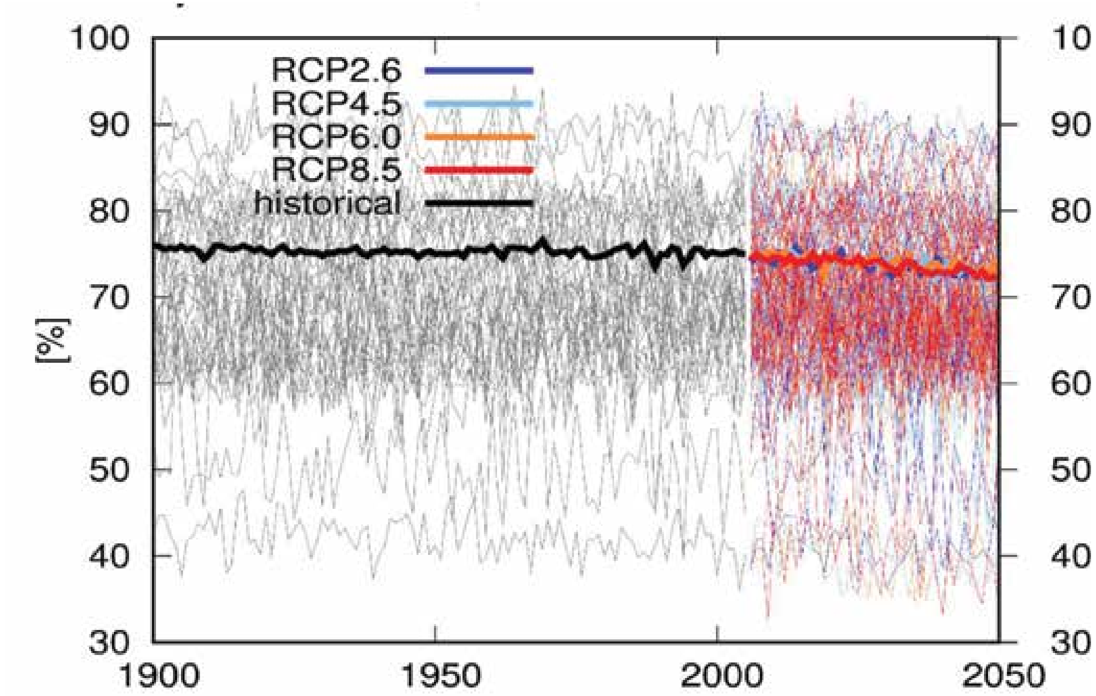


Figure 24: Projections of PET for Gilgit under all emissions scenarios

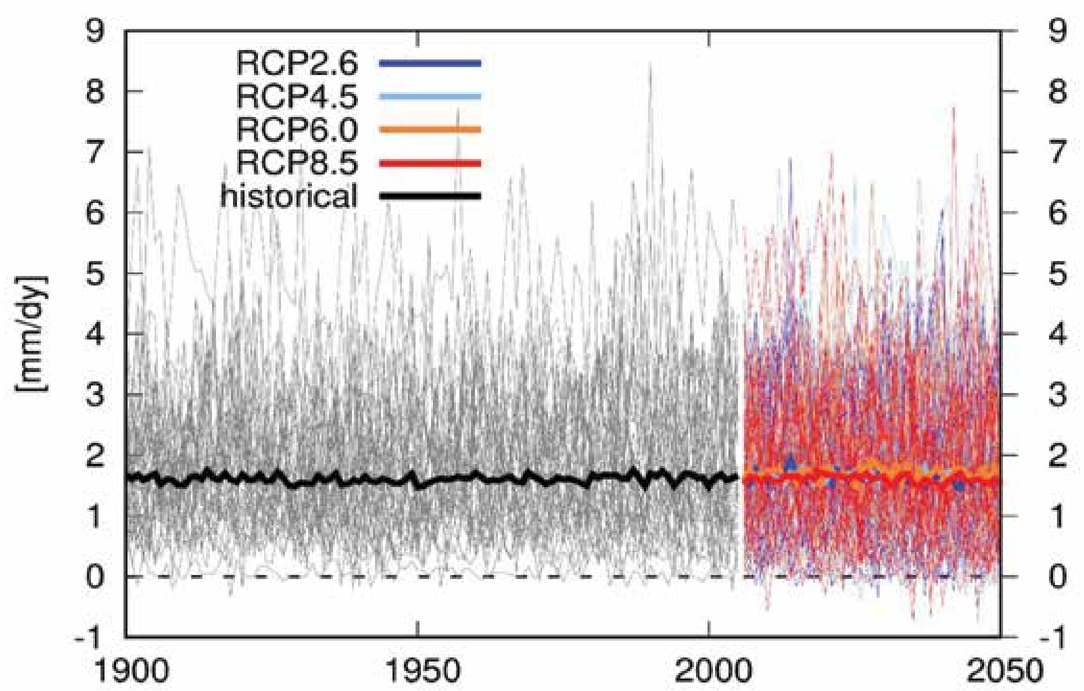


Figure 26: Projections of PET for Ghizer under all emissions scenarios

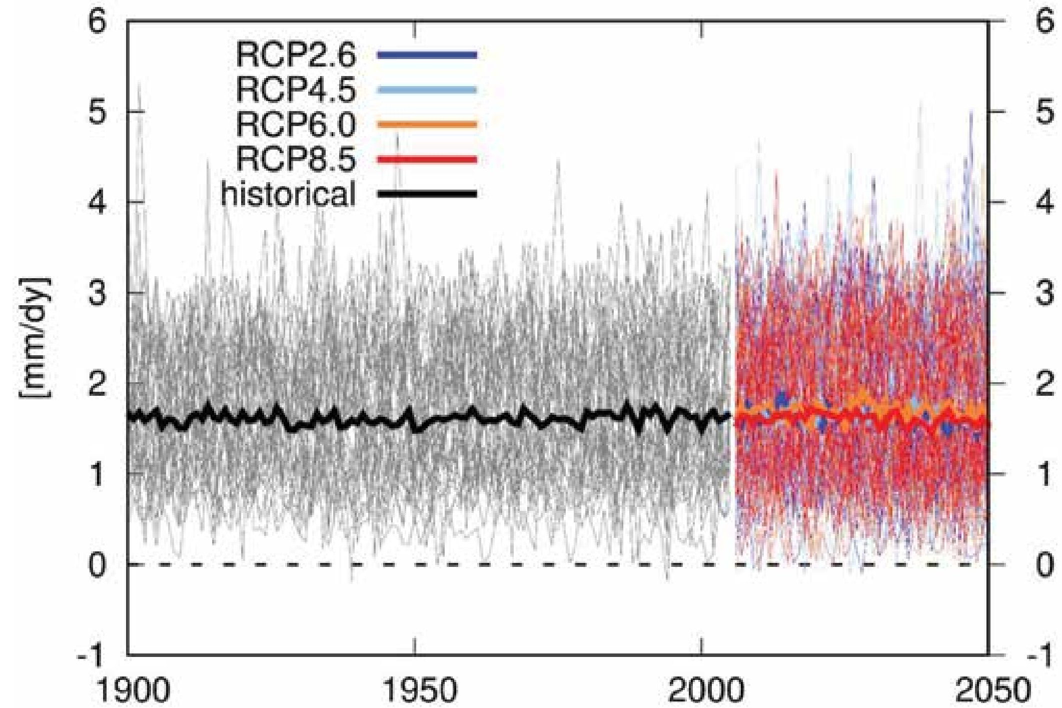
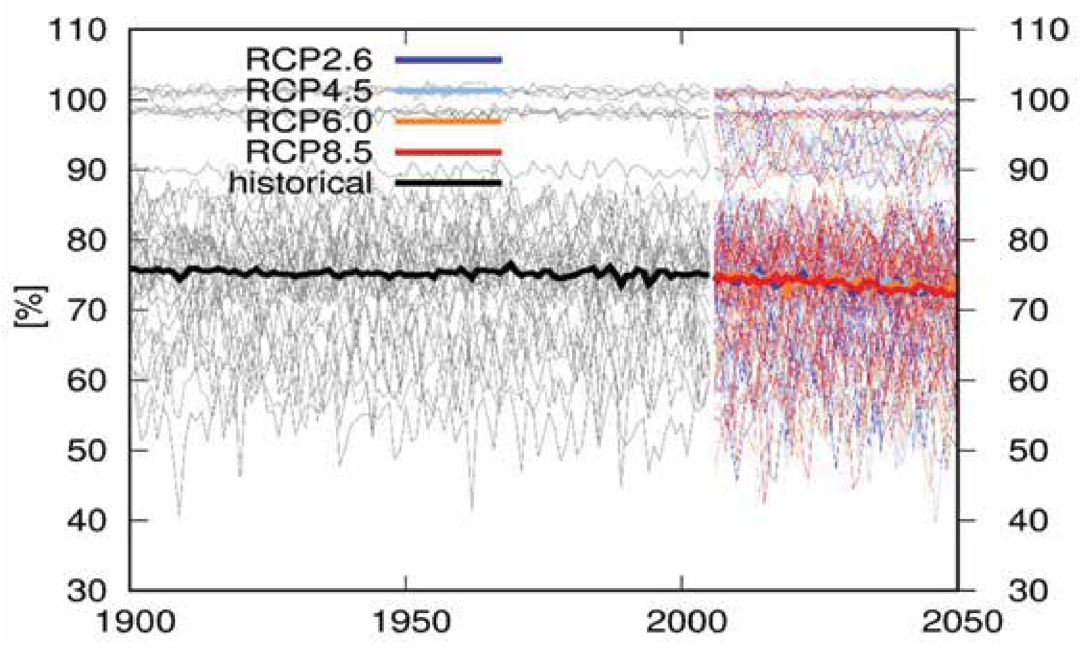
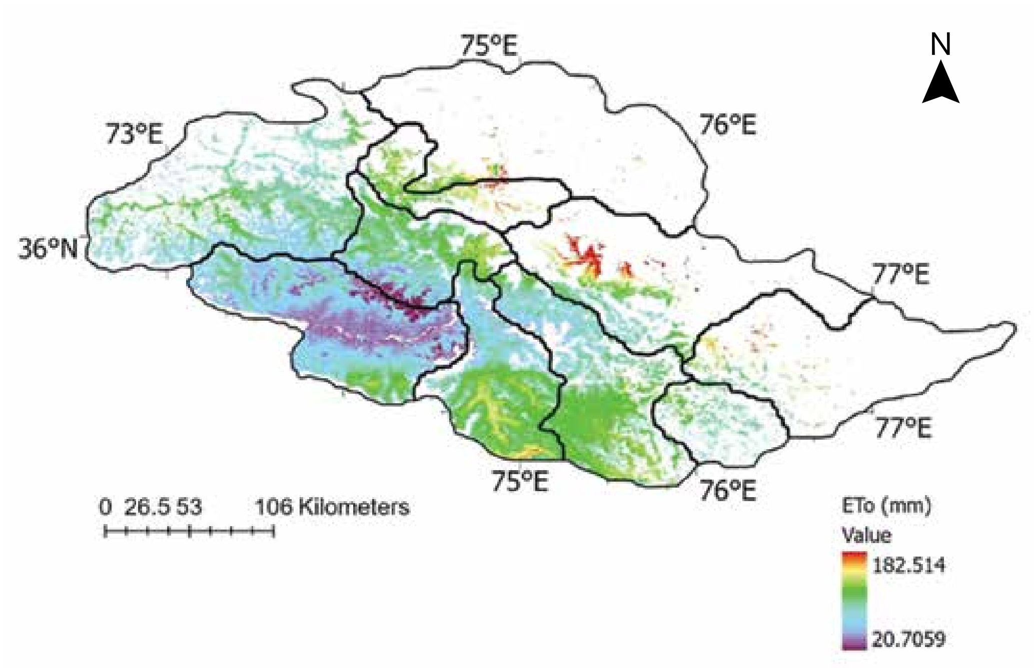


Figure 27: Projections of Relative Humidity for Ghizer under all emissions scenarios



Since the PET is not showing any significant variation, and that in GB crops are grown on irrigation water, the weightage given to PET in defining the AEZ is low. PET map for entire GB for summer 2021 is given in **Figure 28**.

Figure 28: Potential Evapo-Transpiration map GB (summer 2021)



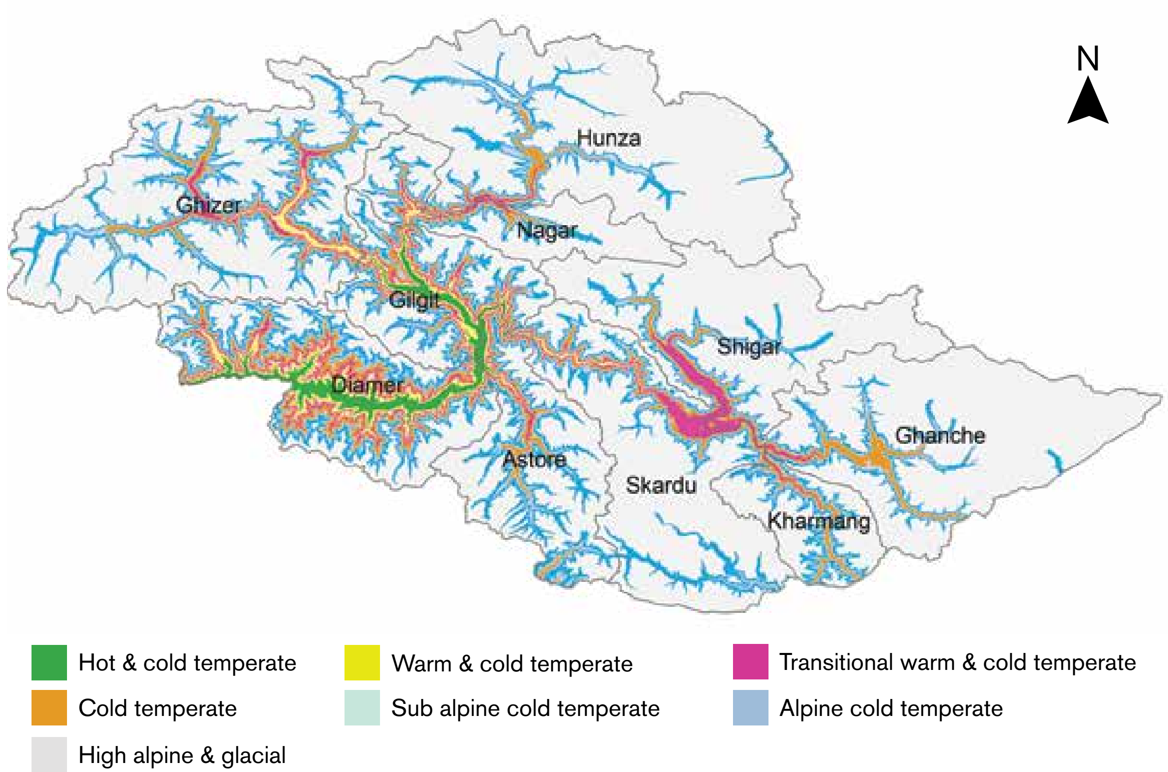
8. Agro-Ecological Zones of Gilgit-Baltistan

In 1980, the entire GB and adjoining mountain areas of KP province were classified into a single Agro Ecological Zone (AEZ) known as the Northern dry Mountain (**Figure 1**). This study delineates GB into seven AEZs: **Hot & Cold Temperate zone, Warm & Cold Temperate zone, Transitional Warm & Cold Temperate zone, Cold Temperate zone, Sub-Alpine Cold Temperate zone, Alpine Cold Temperate zone, and High Alpine and Glacial zone - (Figure 29).**

8.1. Overall description of AEZs

The AEZs have been classified by overlaying 1. Elevation 2. Land use land cover and 3. Climatic maps. The seven AEZs are spread over different geographical and administrative locations of GB and are not contiguous. This means that a particular AEZ may extend to more than one non-contiguous geographical locations due to similar characteristics as has been explained in section on **Methodology**. Classification of GB into seven AEZs suggests great diversity of agro-ecology across GB. The information used for defining the AEZs reveals an enormous potential for crop diversification in the area. It is expected that this information would help in more realistic agriculture planning for maximizing benefits from the farming sector while minimizing risks posed by climate change.

Figure 29: Agroecological zonation map of GB

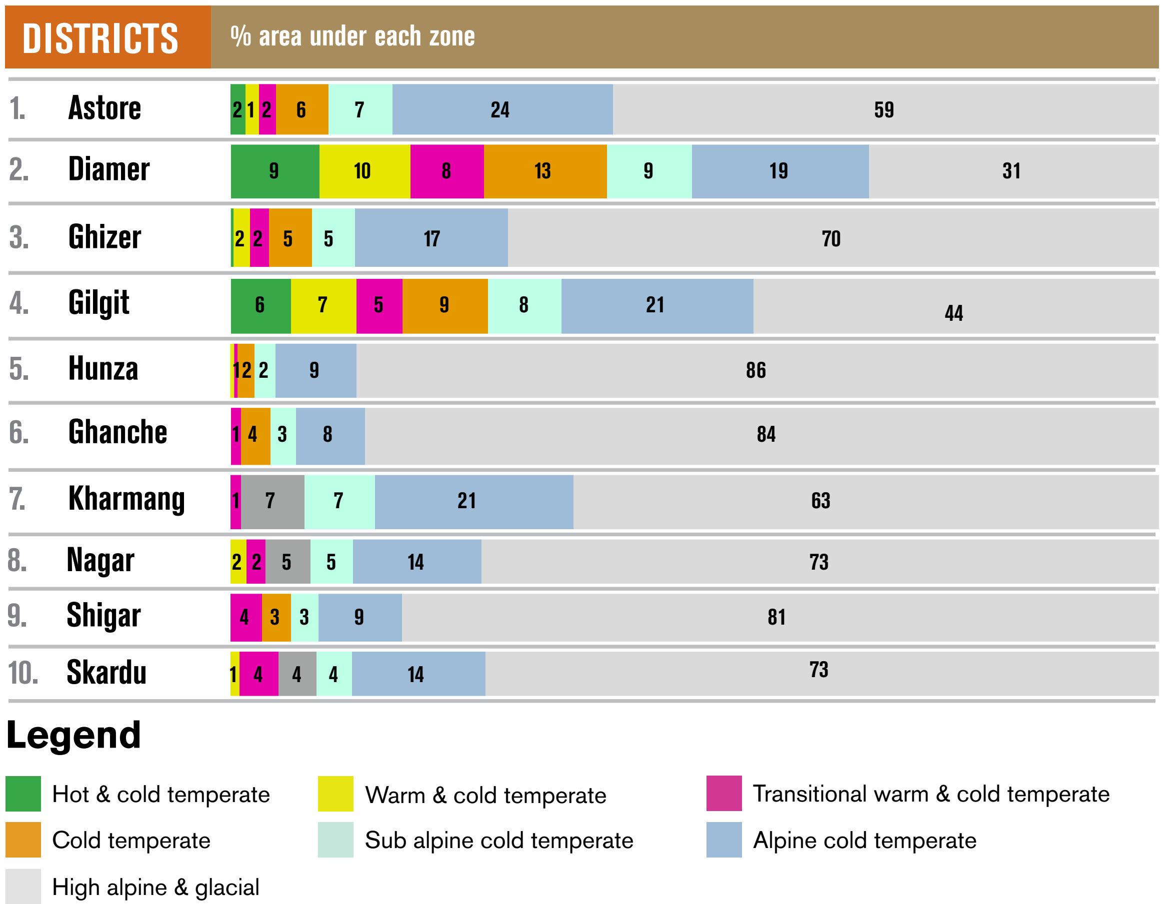


It is important to note that the AEZs are not evenly distributed among the districts. Districts of Astore and Ghizer face the challenge as the most diverse agro-ecologies with prevalence of all seven zones. The diversity of zones by districts will be useful in planning for the agriculture sector including assessing capacities and preparedness. The area occupied by each zone is given in **Table 6**. Visual illustration of prevalence of AEZs by districts is given in **Figure 30**.

Table 6: Percent area covered by each AEZ.

Agro-ecological Zones	Elevation (feet)	Elevation (meters)	Area in sq. km	%age area covered
Zone 1: Hot & Cold Temperate	4,000 – 5,500	1220-1700	1,088	1.5%
Zone 2: Warm & Cold Temperate	5,500 – 7,000	1700-2150	1,450	2%
Zone 3: Transitional Warm & Cold Temperate	7,000 – 8,000	2150-2450	1,957	2.7%
Zone 4: Cold Temperate	8,000 – 9,500	2450-2900	3,697	5.1%
Zone 5: Sub Alpine Cold Temperate	9,500 –10,500	2900-3200	3,407	4.7%
Zone 6: Alpine Cold Temperate	10,500 – 12,500	3200-3800	10,150	14%
Zone 7: High Alpine & Glacial	Above 12,500	Above 3800	50,747	70%
Total area			**72,496**	**100%**

Figure 30: Prevalence of AEZs by type in districts of GB



Elevation, temperature, and precipitation are the most important **determinants** of AEZs in GB. These three characteristics carry the main weightage for defining the AEZs while evapotranspiration and soil type are secondary characteristics. Common climatic characteristics of each AEZ have been described in **Table 7**. It is important to note that the "High alpine and glacial zone" practically falls out of agricultural zone since this zone is too high to support any form of agricultural production. A more detailed description of each AEZ is given in **Table 8** and preceding paragraphs.

Table 7: Climatic characteristics of AEZs of GB

Agro-ecological zones	Temperature Profile (°C)					Precipitation Profile (mm)				
	Average	Winter	Spring	Summer	Autumn	Annual	Winter	Spring	Summer	Autumn
Hot & Cold Temperate zone	4.5	-5.9	4.2	13.2	3.2	427	113	149	133	32
Warm & Cold Temperate zone	4.4	-6.0	4.1	13.1	3.2	389	104	142	112	31
Transitional Warm & Cold Temperate zone	3.9	-6.6	3.5	12.6	2.6	419	112	153	119	35
Cold Temperate zone	3.2	-7.1	2.8	11.8	1.9	441	113	153	142	33
Sub alpine Cold Temperate zone	-3.5	-14.2	-4.1	5.8	-4.9	339	98	132	81	27
Alpine Cold Temperate zone	-4.0	-14.6	-4.7	5.4	-5.6	259	80	111	45	23
High alpine and glacial zone	-7.1	-17.7	-8.0	2.4	-8.8	227	78	109	18	23

Table 8: Detailed characteristics of AEZs of GB

Zone number	Classification[47]	Weather/Climate	Average Temp (^0C)	Annual Precipitation (mm)	Elevation	Soil
1	**Hot & Cold Temperate zone**	Avg. Evapotranspiration: 2.4 mm/day Dec – Feb: Dry and cold Mar – May: Dry and warm Jun and Sep: Dry and hot Jul-Aug: Dry and very hot Oct – Nov: Dry and mild cold	4.5	427	4,000 – 5,500 feet 1,220 – 1,700 meters	Generally shallow, yet among productive mountain soils. Parent material mostly Eutric, Cambisols and Lithosols. Average to adequate organic material. Sometimes slightly acidic tendency in pH.
2	**Warm & Cold Temperate zone**	Avg. Evapotranspiration: 2.4 mm/day Dec – Mar: Dry and cold Apr – May: Dry and warm Jun – Sep: Dry and Hot Oct – Nov: Dry and mild cold	4.4	389	5,500 – 7,000 feet 1,720 – 2,150 meters	Generally shallow, yet among the most productive mountain soils. Parent material Eutric Cambisols and Lithosols. Adequate organic material. pH generally alkaline.
3	**Transitional Warm & Cold Temperate zone**	Avg. Evapotranspiration: 2.3 mm/day Dec – Feb: Dry and very cold Mar – April: Dry and cold May, Jun, and Sep: Dry and warm Jul-Aug: Dry and Hot Oct – Nov: Dry and mild cold	3.9	419	7,000 – 8,000 feet 2,150 – 2,450 meters	Generally shallow, yet productive soils. Parent material Eutric Cambisols and Lithosols. Nutrient deficient. pH generally neutral to alkaline.
4	**Cold Temperate zone**	Avg. Evapotranspiration: 2.3 mm/day Dec – Feb: Dry and very cold Mar and Nov: Dry and cold April and Oct: Dry and mild cold May – Sep: Dry and warm	3.2	441	8,000 – 9,500 feet 2,450 – 2,900 meters	Generally shallow soils. Parent material mostly Eutric Cambisols and Lithosols. Low organic matter with localized variations. pH generally neutral to alkaline.
5	**Sub Alpine Cold Temperate zone**	Avg. Evapotranspiration: 2.1 mm/day Dec – Feb: Dry and harsh cold Mar and Nov: Dry and very cold April and Oct: Dry and cold May and Sep: Dry and mild cold Jun-Aug: Dry and warm	-3.5	339	9,500 – 10,500 feet 2,900 – 3,200 meters	Generally shallow soils. Parent material mostly Eutric Cambisols and Lithosols. Average on organic matter. pH generally alkaline.
6	**Alpine Cold Temperate zone**	Avg. Evapotranspiration: 2.1 mm/day Nov – Mar: Dry and harsh cold Apr and Oct: Dry and very cold May and Sep: Dry and cold 15 Jun-15 Aug: Dry and warm	-4	259	10,500 – 12,500 feet 3,200 – 3,800 meters	Generally shallow soils. Mixed parent material with all four varieties respectively Eutric Cambisols, Gleysols, Lithosols, and Orthic Acrisols. Medium organic material with low activity due to cold temperature. pH generally mixed and fluctuates between slightly acidic to neutral.
7	**High Alpine and Glacial zone**	Avg. Evapotranspiration: 1.9 mm/day Oct – Apr: Dry and harsh cold May, Jun, Aug, and Sep: Dry and cold Jul: Dry and warm	-7.1	227	Above 3,800 meters	Generally rocky or shallow soils just to support grasses. Mostly Gleysols parent material. Poor in organic material, at times frozen. pH generally mixed and fluctuates between slightly acidic to neutral.

[47]Read Temperate as dry temperate

8.2. Description of individual AEZs

Zone 1: Hot & Cold Temperate zone

Hot & Cold Temperate zone lies between elevation of 4,000 to 5,500 feet (1,219 to 1,676 meters) in the valleys along the streams and rivers. It is very hot in summers and cold in winters. It consists of arid eco-sub-region with average annual precipitation of 427 mm majority of which comes in summers. Overall, the region has dry temperate characteristics. The mean annual temperature of the zone is 4.5ºC. Winters are cold followed by warm spring and hot summers. Autumn is mildly cold.

Barren desert areas along the river with scanty trees and pastures, and valley fans with cultivated trees, crops and houses is a common landscape in this zone with river flowing in the middle of the zone across length. Higher steep slopes lacking vegetation with frequent debris flow, especially during rainfall. Cultivated land in the valleys is irrigated with river/glacier fed channels.

Districts / prominent areas in the zone (**Figure 31**):

- **Astore:** Bunji
- **Diamer: Tangir:** Luruk. **Darel:** Phoguch, Sut Das, Gayal, Hedokail Dudishal, Nararay Khanbery, Bailow Khanbary. **Chilas:** Chilas central, Thor Das, Hudur Das, Thalpan Khiner, Lower Gini, Gas Bala and Payeen, Bonner Das, Lower Gonner Farm, Kino Das, Daran Goharabad, Thalichi
- **Gilgit:** Juglot, Pari Bangla, Minawar, Danyor, Gilgit, Baseen, Oshkendas, Jalalabad, Chamogarh, Sultanabad, Jutial, Lower Haramosh, Nomal, Chilmish, Henzel, Bargo, Sherote, Shikyote
- **Ghizer:** Just the gateway of Gulabpur

In this zone, most of the area is at low altitudes in the valleys and all the agriculture depends on irrigation water. Crops are grown throughout the year. Most of the area is double cropping zone. The major representative current crops of this zone include winter wheat, barley, maize, potato, and fodder. Vegetables grown include capsicum, tomato, cucumber, radish, Chinese cabbage, mallow plant and peas. Main fruits produced in this zone are grapes, pomegranate, apricot, peach, plum, walnut, almond, persimmon, and mulberry.

Figure 31: Prevalence of Hot & Cold Temperate zone

Zone 2: Warm & Cold Temperate zone

Warm and Cold Temperate zone lies between elevation of 5,500 to 7,000 feet (1,676 to 2,134 meters) in the valleys along the streams and rivers. It is hot in summers and cold in winters. It consists of hyper-arid eco-sub-region with average annual precipitation of 389 mm majority of which is received in summers. Overall, the region has dry temperate character. The mean annual temperature of the zone is 4.4ºC. Winters are cold followed by warm spring season and hot summers. Autumn is mildly cold in this zone.

Barren steep slopes with scanty trees and pastures and valley fans with cultivated trees, crops, and houses, is a common landscape in this zone with river flowing in the middle of the zone across length. Higher areas are rugged with steep slopes and sparce vegetation of Artemisia and Juniper with frequent debris flow, especially during rain. Cultivated land in the valleys is irrigated with river/glacier fed channels.

Districts / prominent areas in the zone (**Figure 32**):

- **Astore:** Lower Doyan, lower Dashkin and Harcho
- **Diamer: Tangir:** Rim Sheikh, Juglot, Diamer, Gali Payeen and Bala. **Darel:** Samaigal Payeen and Bala, Gumari, Shahi Mahal, Jut Dudishal, Sair, Dasoi Khanbery. **Chilas:** **Hudur**: Dang pehari, Topar Hudur. **Thor:** Sari, Kot, Waray, Thaak, Hachay, Sairdas. **Khinar**: Butogah: Khay, Mashi. **Thak**: Dasar, Thak Kot, Thay Niat; Bunar Nala, Thamarus. **Upper Gonner Farm:** Gais, Duga. **Goharabad:** Goharabad mid, Dirkil, Phuski, Datche.
- **Ghizer:** Punial, Ishkoman, Gupis, Single, Sher Qila, Gulodas, Chatorkhand, Bubur, Hasis, Small, Jaj Bargu, Raushan
- **Gilgit:** Sai Juglot, upper Danyor, Lower Bugrot, upper Haramosh, Chikar Kot, Dass, Damote Juglote.
- **Hunza:** Shinaki (Nasirabad, Hussainabad, Khanabad).
- **Nagar:** Chalt, Sikandar Abad, Jafarabad, Sonikot, Rabat, Akbarabad, Budlas, and Lower Minapin
- **Skardu:** Lower Rondu, lower Basho, Sundas, Qumrah, Katpana, Gamba, Gol, Shangus, Chamachu, Ganji, Talu, Dambodas, Shot, Kushmal

In this zone, most of the area is located in the heart of the valleys and all the agriculture depends on irrigation water. Most of the agriculture in the area takes place during spring and summers and farmers grow one major crop followed by a short duration crop. Some areas are double cropped where winter wheat and early spring vegetables are also grown. Major representative crops of this zone include potato, wheat, maize, barley, and pulses. Vegetables grown include peas, tomato, radish, capsicum, cauliflower, and turnip. Fruits produced in this zone are, cherry, apple, apricot, almond, mulberry, walnut, grapes, pomegranate, peach, and pear. Fast expansion of cherry has taken place in this zone during the last two decades.

Figure 32: Prevalence of Warm & Cold Temperate zone

Zone 3: Transitional Warm & Cold Temperate zone

Transitional Warm & Cold Temperate zone lies between elevation of 7,000 to 8,000 feet (2,134 to 2,438 meters) in the valleys along the streams and rivers. It is warm to hot in summers, very cold in winters, consists of hyper arid eco-sub-region with an average annual precipitation of 419 mm majority of which is received in spring and summers. Overall region is dry throughout the year. The mean annual temperature of the zone is 3.9 ^{0}C. Winters are very cold followed by cold spring season and warm-hot summers. Autumn is mildly cold. The reason this zone is called transitional is that the indicators are such that with rising temperatures this zone may eventually merge into warm & cold zone.

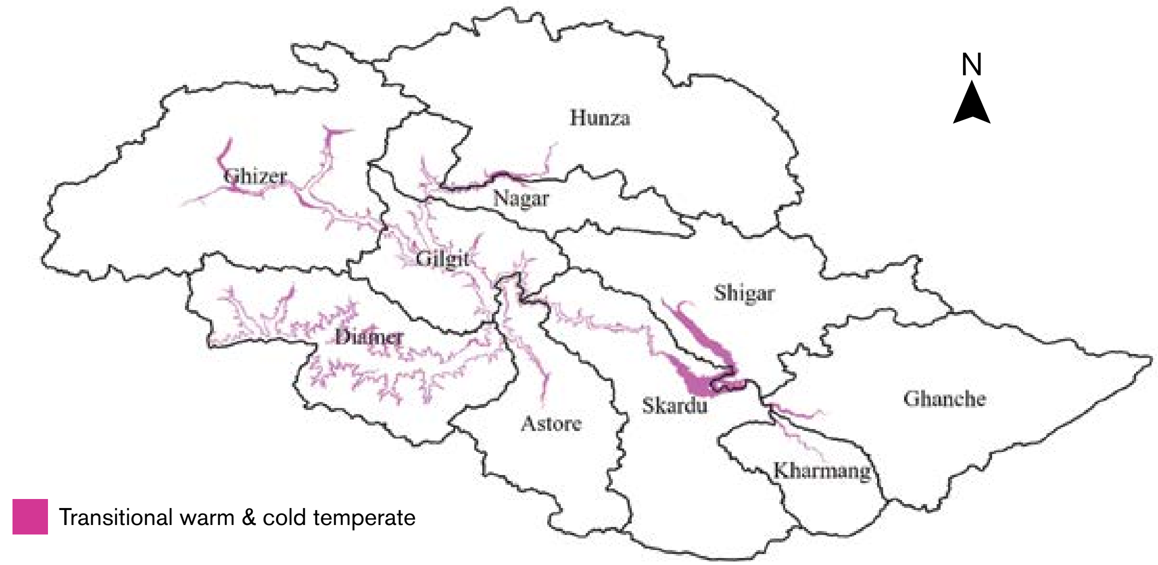
Huge barren steep slopes with scanty trees and pastures and valley fans with cultivated trees, crops and houses is a common landscape in this zone with river flowing in the middle of the zone across length. Cultivated land in the valleys is irrigated with river/glacier fed channels.

Districts / prominent areas in the zone (**Figure 33**):

- **Astore**: Shogrot, Hapuk, Datch, Lous, Fina, Bulan, Eidgah, Gorikot.
- **Diamer: Tangir:** Phaphat, Korangai. **Darel:** Manikal Payeen, Manikal Bala, Biari, Geot, Khanbery: Gishar, Dabot, Khurin. **Chilas: Hudur** – Molodas, **Thor** – Doga, Dyong. **Khiner** – Totam. **Butogah:** Chakar, Beraydat. **Thak:** Dyong, Loshi. Gushar, proper Niat. **Goharabad upper:** Khartalot, Gittelay
- **Ghanche:** Keris, Ghowari, Kuru, Kharfaq, Daghoni Balghar, Yugo, Kharko, Barah.
- **Ghizer:** Gupis, Damalgal, Main Ishkoman, Bar Jungle, Imit, Gindai, Proper Yasin, Sultanabad, Taus, Dahimal and Khalti.
- **Gilgit:** Bagrot (Datoche, Harpu, Opaei, Bilchar, Chira), lower Naltar, lower Kargah, Sabeel Juglote.
- **Hunza:** Murtazabad, Aliabad, Hassanabad, Hyderabad, Karimabad, Ganish, Altit.
- **Kharmang:** Mehdiabad, Tolti, lower Pari, Ghasing, Manthoka, Madhupur, Kamangu, Kharmang Khas, Susithang, Baghecha.
- **Nagar:** Askurdas, main Nagar (Nagar Khas), Sumayr, Lower Bar, Upper Minapin, Nilt, Miachar, Dadimal, Balakot, Hakuchar, Chaprot.
- **Shigar:** Sarfaranga, Lamsa, Kothang, Churka, Nar Ghoro, Narbocho, Markenja, Alchori, Hashupi, Hurchus, Sildi, Kashmal, Yono, Hyderabad, Baha, Tesar lower, Gulabpur, Wazirpur, Lagaf
- **Skardu:** Mid Rondu, lower Gultari, Hussainabad, Bilamik, Talubrok, Stak, Tormik, Khomer, Hengu, Hardas, and Upper Kachora

Most of the area in this zone is at higher altitudes in the valleys and all the agriculture depends on irrigation water. Most of the area is single cropping zone with few exceptions. Due to variation in altitude, the crops and fruits grown within a zone are diverse. Major representative crops of this zone include wheat, maize, barley, millet, and potato. Vegetables grown include red beans, tomato, garlic, turnip, onion, cauliflower, peas, chilies, carrot, cucumber, cabbage, okra, bottle gourd and spinach. Fruits produced in this zone are apple, apricot, almond, mulberry, cherry, grapes, walnut, pomegranate, pear, peach, fig and plum.

Figure 33: Prevalence of Transitional Warm & Cold Temperate zone



Zone 4: Cold Temperate zone

Cold Temperate zone lies between elevation of 8,000 to 9,500 feet (2,438 to 2,896 meters) in the valleys along the nullahs, streams and rivers. Summers are warm in this zone with very cold winters. It consists of hyper arid eco-sub-region with average annual precipitation of 441 mm majority of which is received in spring and summers. Overall region is dry throughout the year. The mean annual temperature of the zone is 3.2^{0}C. Winters are very cold followed by cold spring season and pleasantly warm summers. Autumn is cold in this zone.

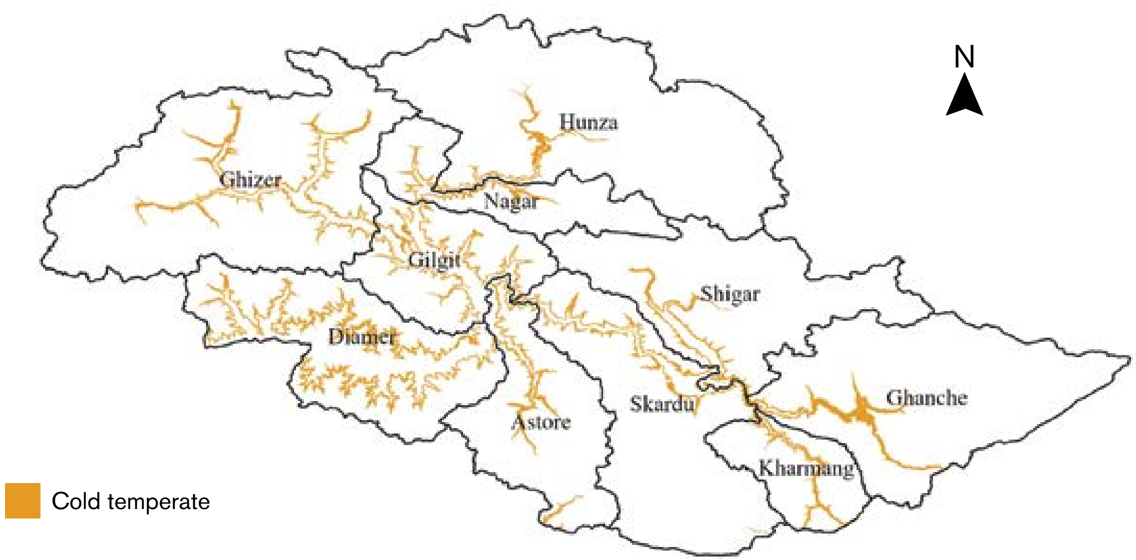
Evergreen forests with pine and juniper trees and pastures and valley fans with cultivated trees, crops, and houses (with more forest area in Nagar, Astore and Diamer compared to other areas in this zone) is a common landscape in this zone with river flowing in the middle of the settlements either side of the rivers. Cultivated land in the valleys is irrigated with river/glacier fed channels.

Districts / prominent areas in the zone (**Figure 34**):

- **Astore:** Makial, Pakora, Kushinat, Zail, Khomay, Gudai, Rehmanpur, Chorit, Zaipur, Tarishing, Chowgam, Dashkin Bala, Mushkin, Doyan Bala Choungra, Sheype, Palyat, Mushkay, Dodugai, Ziyan
- **Diamer: Tangir:** Sateel Tangir, Upper Korangai. **Darel:** Gabar, Yashot, Jaduri, Khanbery Manin, Thilkush, Banogah. **Chilas:** Hudur: Suri chap. **Thor:** Makhili. **Babusar:** Lower Babusar, Niat Khatay. **Batogah:** Sumall, Martel. **Goharabad:** Damreli, Tatto Muthat
- **Ghanche**: Saling, Khaplu (lower), Ghursey, Surmo, Yuchung
- **Ghizer:** Phandar lower, Pingal, Chashi, Upper Ishkoman, upper Yasin (Nazbar, Thoi, Barkolti)
- **Gilgit:** Upper Bagrot, Upper Haramosh, Naltar bala, Kargah Joot
- **Hunza:** Altit, Duikar, Ahmadabad, Khyber, Gulmit, Shishkat, Passu, Sost, and Khudabad
- **Kharmang:** Pari, Upper Gundus, Mayurda, Hamzigond, Sinkarmo, Moral
- **Nagar:** Hoper, Bar upper (khas), lower Hispar, Fekar, lower Diater valley, Pissan, Gulmit, lower Gappa valley
- **Skardu: Upper** Rondu, Skardu, Hussainabad, Upper Bilamik, Upper Talubrok, Upper Stak, Upper Tormik, Khomer, Hengu, Hardas and Upper Kachora
- **Shigar:** Dasu, Lower Braldo (Apoaligon, Folju), Lower Basha (Chutrun, Thorgo, Damel, Zil, Doko)

The zone is located at high altitudes in the valleys. As elsewhere, all the agriculture depends on irrigation water. Crops are grown during the spring and summer seasons only. Most of the area is single cropping zone. The major representative crops include wheat (spring), maize, potato, barley, millet, and buckwheat. Vegetables grown include tomato, reddish, cabbage, cauliflower, turnip, peas, red beans, carrot, and chilies. Fruits produced in this zone are apricot, mulberry, apple, walnut, cherry, almond, peach, , pear, and plum.

Figure 34: Prevalence of Cold Temperate zone



Zone 5: Sub Alpine Cold Temperate zone

This zone lies between elevation of 9,500 to 10,500 feet (2,896 to 3,200 meters) in the valleys along the nullahs, streams and rivers at higher altitudes. Winters are long and harsh whereas the short summers are warm. It consists of hyper arid eco-sub-region with average annual precipitation of 339 mm majority of which is received in winters and spring. Overall region is dry throughout the year. The mean annual temperature of the zone is -3.5°C. Winters are harsh and long followed by very cold spring season and slightly warm summers with warm days and cold nights.

Huge steep slopes with scanty trees at lower alleviation and denser forests and green pastures at higher alleviation with crops and houses is a common landscape in this zone. Snow and glacier melt streams are frequent in this zone, joining valley rivers. Evergreen conifer forests and juniper exist in some of these areas (Astore, Diamer, Nagar, and in some valley in Skardu). Cultivated land in the valleys is irrigated with river/glacier fed channels.

Districts / prominent areas in the zone (**Figure 35)**:

- **Astore:** Nasirabad, Kulalot, Rattu, Dadojail, Chaien, Gorial Jutte, Faqirkot, Rupal, Nowgam, Aigah, Yagam, Kharbay, Dirlay, Ispay, Shankar Gardh, Sakamal
- **Diamer: Darel:** Dubulus (Gayal Darel), Matikeh, Aat. Khanbery: Datay. **Niat:** Kaami, Babusar. **Chilas:** Goharabad: Gais Payeen, kosach
- **Ghanche:** Khaplu (upper), Happy, Gharbuchung, lower Thallay, lower Hushe, Surmo Broq, Thalis, Machulu, Balay Ghund
- **Ghizer:** Darkut, Upper Phandar, Handrup and Teru
- **Gilgit:** Higher areas, mainly pastures
- **Hunza:** Shimshal, Chipursan and Misgar
- **Kharmang:** Olding, Torghun, Ganokh, Kendrik, Katisho, Inguth, Mamosh Thang
- **Nagar:** Upper Hispar, upper Hopper, upper Bar (Bar Das), upper Chaprot, upper Gappa, upper Diater, Hapakun Hoper
- **Skardu:** Gultari, Rondu, Skardu, Gultari (Chaqma, Bunial, Phultukus), Nazimabad Basho
- **Shigar:** Upper Braldo (Askoli, Tiston), Upper Basha (Besil, Arandu)

This zone is at very high altitudes with lightly warm summers. Crops are grown in a small window with very low production. In this cropping zone farmers hardly manage one crop which is evident from the less diverse crops grown in this zone. Farmers prefer short duration crops that can be harvested in the short growing season. The major crops include potato, maize (fodder), barley, and buckwheat. Vegetables grown include peas, cabbage, and turnip. Fruits produced in this zone are apricot mulberry and walnut.

Figure 35: Prevalence of Sub alpine Cold Temperate zone

Zone 6: Alpine Cold Temperate zone

Alpine Cold Temperate zone lies between elevation of 10,500 to 12,500 feet (3,200 to 3,810 meters). Winters are long and harsh whereas summers are warm and brief. Harsh and long winters are followed by very cold spring season and slightly warm summers with warm days and cold nights. Autumn is also very cold in this zone. It consists of hyper arid eco-sub-region with average annual precipitation of 259 mm majority of which is received in winters and spring. Overall region is dry throughout the year. The mean annual temperature of the zone is -4.0^{0}C.

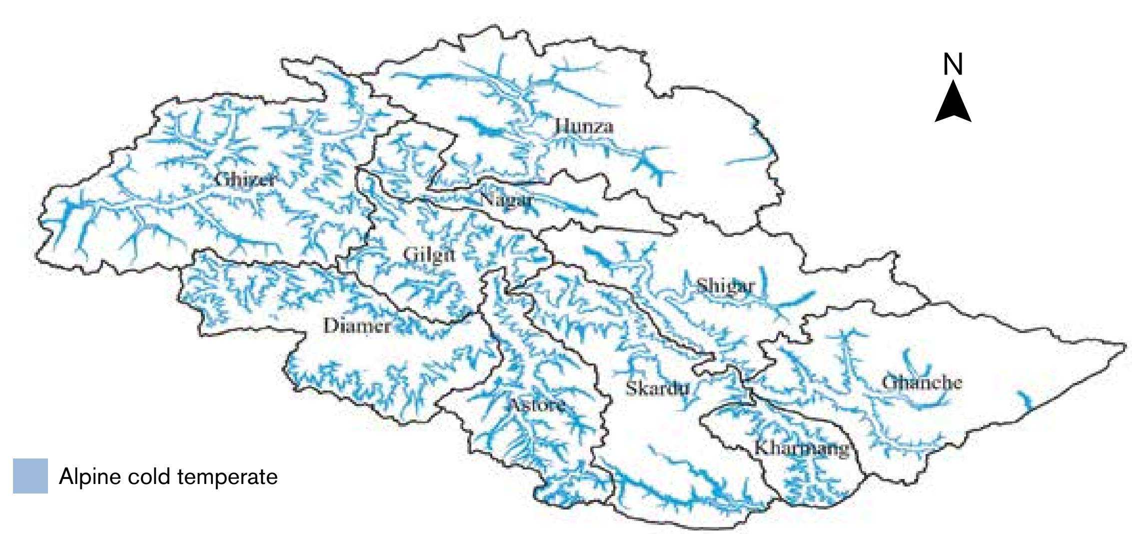
Natural conifer and birch forest exist in some areas in this zone with vast green pastures, crops and houses among the green flat/slop areas. Lower slopes in some areas have ever green conifer forest with birth on higher ridges. Livestock farming is an important source of livelihoods.

Districts / prominent areas in the zone (**Figure 36**):

- **Astore:** Chilim, Minimarg, Qamri, Mir Malik, Thing Payan & Bala, Gutum Sir, Chiti Nadi, Gishat, Kalshai, Tetwal, Grat Nallah, Guzair
- **Diamer: Darel:** Matikeh summer settlement, Diagarh Gayal, Khanbery: Naroon Namal, Narnaygah. **Chilas:** Koota Babusar, Fairy Meadows, Malpat
- **Ghanche:** Hanjol, Ihly, Upper Thallay, Upper Hushe, Dumsum, Kudus, Saltoro, Goma, Gulshan-e-Kabir, Chorbut
- **Ghizer:** Teru upper
- **Gilgit:** Mainly pastures
- **Hunza:** Upper Shimshal, Upper Chipursan (Baba Ghundi), Upper Misgar
- **Nagar:** Barpu, Hamadar areas of Hoper
- **Kharmang:** Tololing, Dapa, Donga, Harghosil, Memosh, Upper Kendrik
- **Skardu:** Upper Gultari (Shingo Shigar, Nowgam, Gultari proper, Matial, Ganial), Shilla, Dappa, Sultanabad Basho
- Shigar: Pastures

In the very small window of growing season, farmers grow barley, potato, peas, and turnip. Fodder is produced in irrigated pasture and also collected from rainfed pastures.

Figure 36: Prevalence of Alpine Cold Temperate zone



Zone 7: High Alpine and Glacial zone

High Alpine and Glacial zone lies above the elevation of 12,500 feet (3,810 meters and above). Winters are harsh and long followed by very cold spring season and slightly warm brief summers. Autumn is also very cold in this zone. It consists of hyper arid eco-sub-region with average annual precipitation of 227 mm majority of which is received in winters and spring. Overall, this zone is dry throughout the year. The mean annual temperature of the zone is -7.1^{0}C. This zone has vast green pastures in lower altitudes and snow bound high mountains.

Districts included (**Figure 37**):
High altitude alpine areas and glaciers of Skardu, Kharmang, Ghanche, Nagar, Diamer, Gilgit, Astore, Hunza, Ghizer and Shigar.

No agricultural activity takes place in this zone and pastures situated on lower altitude of this zone are used as summer grazing grounds.

Figure 37: Prevalence of High Alpines and Glacial zone

9. Crop potential with economic considerations

The primary objective of this section is to determine production potential of various crop as per climatic and physical characteristics of various zones. The second objective is to prioritise crops based on economic potential of the zones to take GB from a mostly subsistence economy to cash economy. Economic analysis of selected crops has been included for comparative analysis to support decision-making and investment.

Despite altitudinal and climate variation across various zones in GB, several crops are grown in multiple zones (e.g., wheat, maize, potato, cherry, apricot, and many vegetables). All these crops seem to grow well in different zones, however, there is a difference between crops being able to grow and having a reliable economic viability in different zones. Based on primary data, this section proposes economic gradient for decision makers on choice of crops, vegetables and fruits, for various AEZs.

The economic analysis was conducted by combining two datasets (see methodology section for details). First, an economic analysis of key crops grown in various AEZs was conducted using data collected directly from farmers and officials of the GB Agriculture department. To triangulate these results, an online survey was conducted where 22 experts of the Agriculture department from all 10 districts participated. Interestingly, the respondents prioritised the same crops (95%) for economic viability which were also shortlisted through the economic survey. Overall prioritization of crops by zones was conducted on the basis of (i) yield (ii) cost of production (iii) market value of produce, and (iv) market demand. The combined results of the two methods for economic viability of crops is given in sub sections **9.1 to 9.7**. Each crop is given a score. Crops scoring 1 signifies least economic viability whereas crops scoring 5 indicates the highest economic viability.

It is important for the decision-makers to recognize that the analysis in this chapter is symbolic and not a last word for decision making. It is just to provide a hint to ensure that while a specific crop may grow nearly everywhere, it may give optimal and economically viable production only in certain zones where optimal environmental and market conditions prevail. Other zones may have alternate crop choices to choose from in the benefit of a farmer. For example, growing wheat and cherry may not be a viable choice in all the zones. Therefore, building on the information provided in this study for six AEZs, a further in-depth study on economics of farming in GB is suggested.

General conclusion from the data given in sub sections 9.1 to 9.7 are as follows:

1. Currently, many crops are grown in most of the zones, however there is a difference in their economic viability in different zones. For example, cherry may be more profitable when grown in Warm & Cold Temperate and Transitional Warm & Cold zones, although cherry can also grow in Cold Temperate Zone. Potato is currently grown in all six zones. However, performance of table potato is far better in Transitional Warm & Cold Temperate, Cold Temperate and Sub alpine Cold Temperate zones while quality of seed potato can be best in Cold Temperate, Sub-Alpine and Alpine zones.

It is suggested to encourage grouping of zones to promote bulk production of certain crops in order to meet local and national (and also international) market demand and revenue generation. For example:

a. Promote persimmon, pomegranate, grapes, capsicum and wheat in the Hot & Cold and Warm & Cold zones.
b. Promote cherry, apricot and reddish in Warm & Cold and Transitional Warm & Cold zones.
c. Promote potato in 3 zones except the first two zones.
d. Promote Carrot, peas, and turnip in Transitional Warm & Cold, Cold Temperate and Sub alpine Cold Temperate zones

1. For grouping zones and prioritizing crops, a workshop of the officials of the agriculture department across GB supported by external experts is strongly suggested which may be founded on information provided in this and other studies. With the current low yield, wheat is not profitable in any zone. However, with significant yield improvement, cultivation of wheat in the Hot & Cold and Warm & Cold zones may be economically viable especially if subsidy on wheat is withdrawn resulting in wheat fetching higher prices locally. Cultivation of wheat in other zones will not be viable at all. However, wheat and any other cereal crop (e.g., maize, barley, buckwheat) if cultivated for meeting subsistence needs, profitability may not be a key consideration.
2. In terms of profitability, vegetables surpass potato and cereal crops in Hot & Cold and Warm & Cold zones.
3. Tomato and cucumber are performing well in terms of profitability in Hot, Warm and Transitional temperate zones, particularly in vertical farming method.
4. Potato performs well in terms of profitability in Cold temperate zone.
5. Peas are highly profitable in colder zones (transitional Warm & Cold, Cold temperate and sub alpine zones).
6. Buckwheat is profitable in colder zones (Transitional and Cold temperate) when cultivated after barley.

9.1. Hot & Cold Temperate Zone

Since the growing season in this zone is longer (in some areas round the year e.g., Chilas, Bunji), the list of economically viable crops is relatively longer. Capsicum, tomato, okra, cucumber, onion, and garlic are the best performing vegetables followed by maize and wheat among crops. Wheat is grown in winter and does not compete with other crops. Wheat may be of commercial value if subsidy on wheat in GB is withdrawn. Cultivation of wheat may, however, only be economically viable if agronomic practices are drastically improved and that crop yield is considerably improved (see section 1.4.4 on agricultural productivity gap in GB). Pomegranate, grapes, and persimmon are the most economically viable fruits. This zone supports growth of apricot. However, apricots are better grown in other zones and therefore, this zone has a niche for fruits which may not perform well in higher altitude areas. It is important to note that both pomegranate and grapes need varietal improvement. The current varieties are not best known for commercial markets and mainly sold in local markets. Alternatively, commercial value of the current pomegranate variety has to be explored, if exists. **Figures 38 and 39** indicate priority of crops for this zone.

Figure 38. Crop prioritization for Hot & Cold Temperate zone
(Scale 1-5 where 5 is highly recommended)

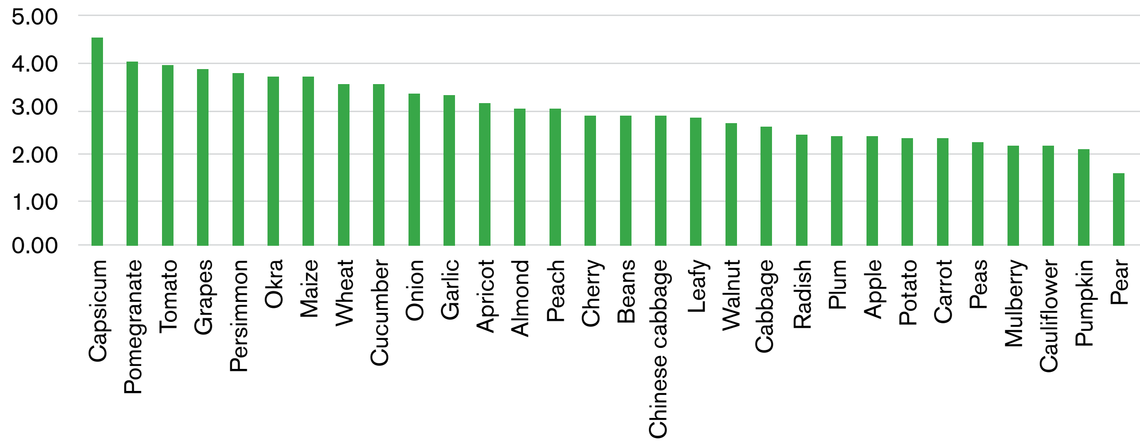
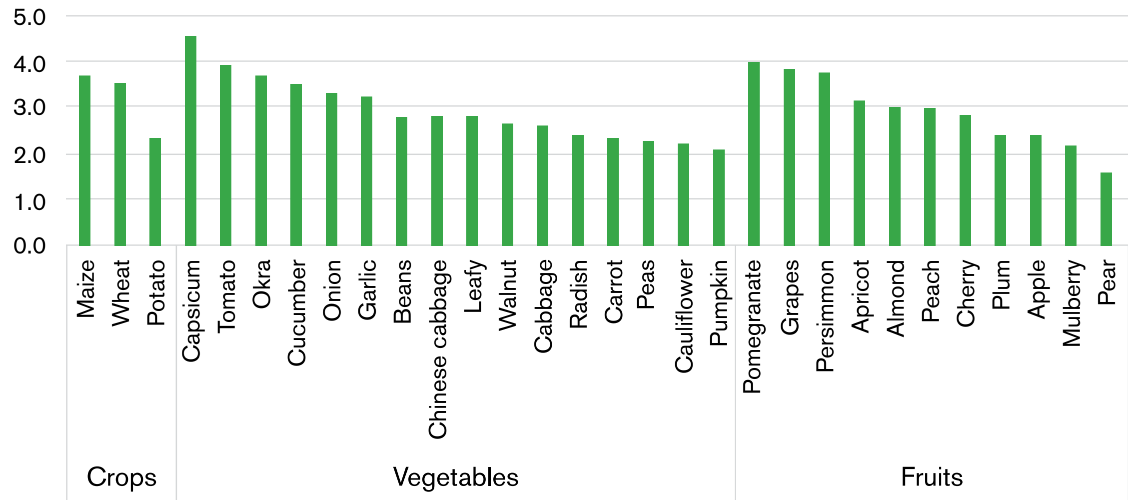


Figure 39. Crop prioritization by crop type for Hot & Cold Temperate zone
(Scale 1-5 where 5 is highly recommended)



9.2. Warm and Cold Temperate Zone

Tomato, capsicum, cucumber, and onion are economically most viable vegetables in this zone. Grapes, cherry, apricot, apple, persimmon, pomegranate, and almond are economically profitable fruits. Warm & Cold and Hot & Cold zones have the potential to grow similar vegetables and fruits (e.g., Capsicum and persimmon, grapes, pomegranate) to produce larger quantities to meet market demand. Potato, wheat, and maize are the three crops that are less profitable than vegetables and fruits, but more economical than any other crops.

Varietal improvement of grapes and pomegranate is needed as has been noted for Hot & Cold Zone. Wheat in this zone is mostly sown in winter and does not compete with other crops. Wheat may be a commercial crop to be supplied to colder areas of GB in case subsidy on wheat is withdrawn. Although, apricot also grows well in this area, other zones compete better in production of apricot. Therefore, it is suggested to focus on fruits, which do not grow well in colder regions. **Figures 40 and 41** indicate priority of crops for this zone.

Figure 40. Crop prioritization for Warm & Cold Temperate zone
(scale 1-5 where 5 is highly recommended)

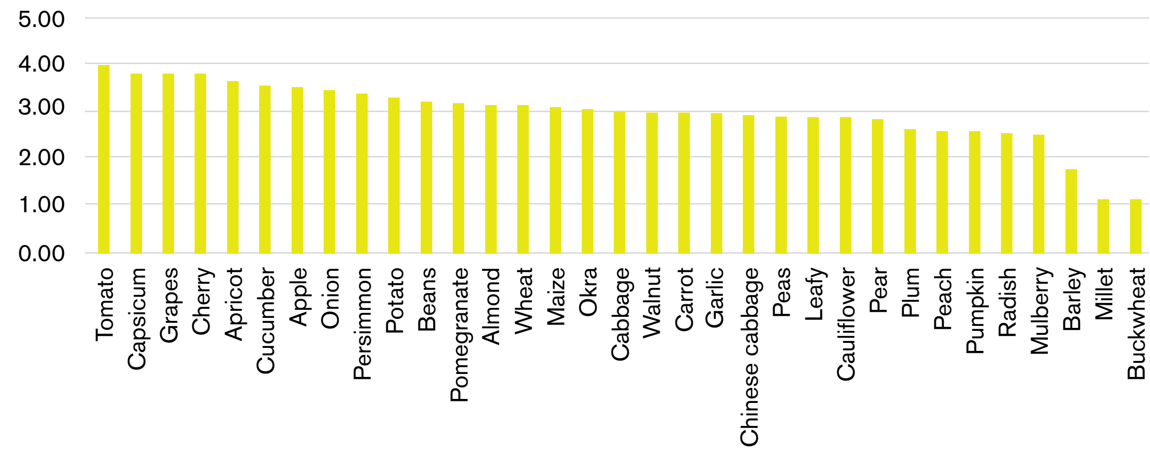
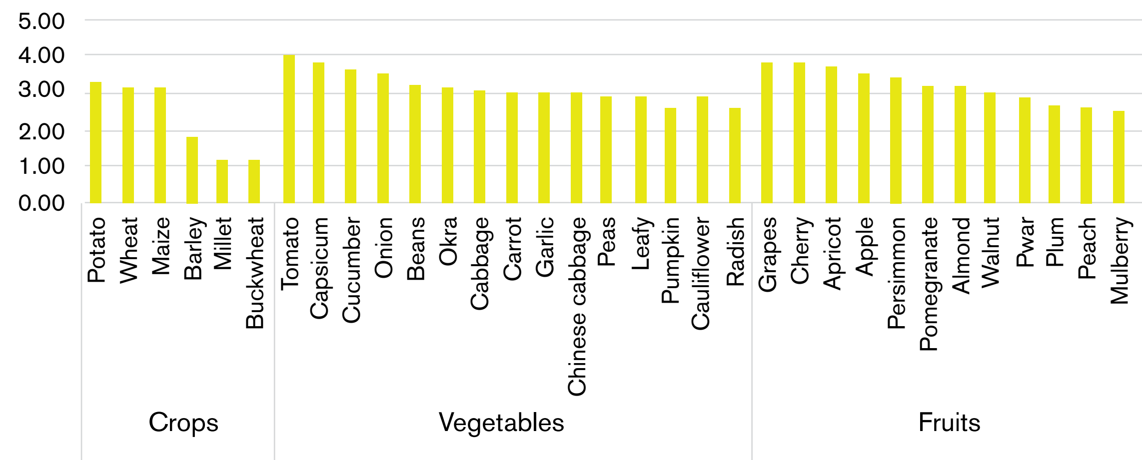


Figure 41. Crop prioritization by crop type for Warm & Cold Temperate zone
(scale 1-5 where 5 is highly recommended)



9.3. Transitional Warm and Cold Zone

Potato is the only economically viable crop in the zone. Wheat should be discouraged which competes with summer corps including potato. If buckwheat finds a national/international market, cultivation of barley followed by buckwheat may be economically suitable. Peas, tomato, cucumber, and beans are economically viable vegetables. Since tomato is perishable, it is suggested to promote peas, cucumber, beans, onion, cabbage, and cauliflower that have greater shelf-life. Apple, cherry, apricot, and walnut are the economically viable fruits in this zone (**Figures 42 and 43**).

Figure 42. Crop prioritization for Transitional Warm & Cold Temperate zone (Scale 1-5 where 5 is highly recommended)

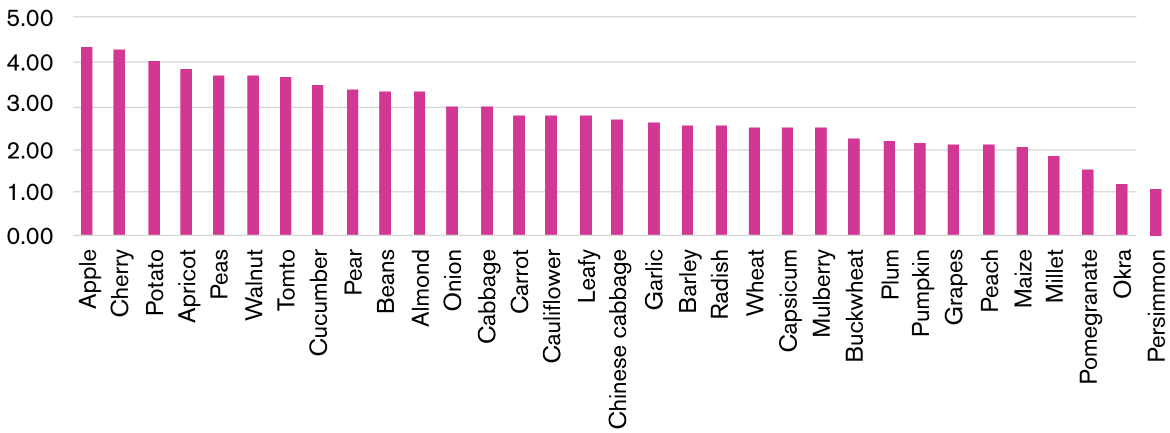
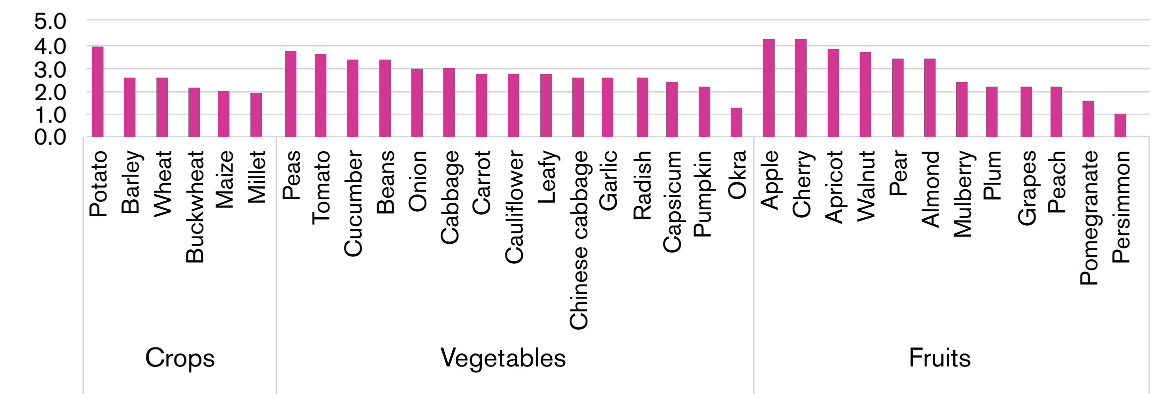


Figure 43. Crop prioritization crop by type for Transitional Warm & Cold Temperate zone (Scale 1-5 where 5 is highly recommended)



9.4. Cold Temperate Zone

Potato is the most economically viable crop in this zone. As mentioned for the Transitional zone, if buckwheat finds a national/international market, cultivation of barley followed by buckwheat may also be an economically viable decision. Peas and beans are economically viable vegetables. Longer shelf-life vegetables such as reddish, carrot and cucumber could be grown for commercial purposes in areas with better roads to access markets. Apple, walnut, and apricot may be priority fruits for commercial fruits of this zone. **Figures 44 and 45** indicate priority of crops for this zone.

Figure 44. Crop prioritization for Cold Temperate zone (Scale 1-5 where 5 is highly recommended)

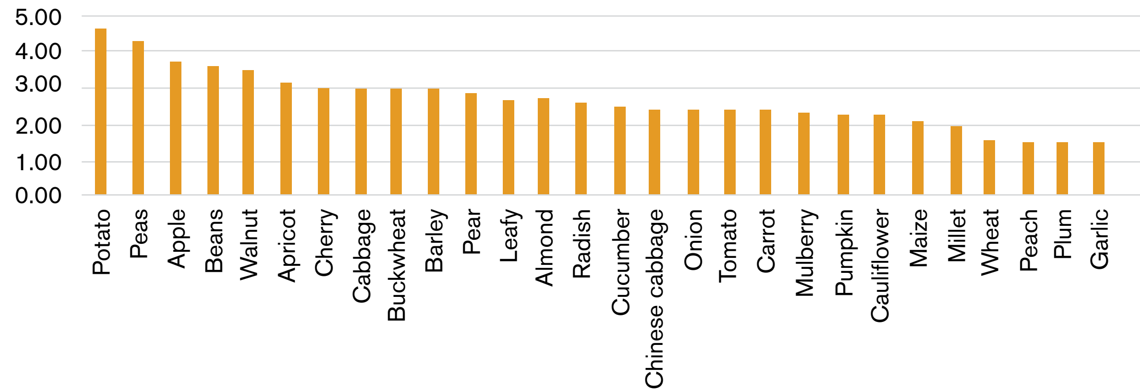
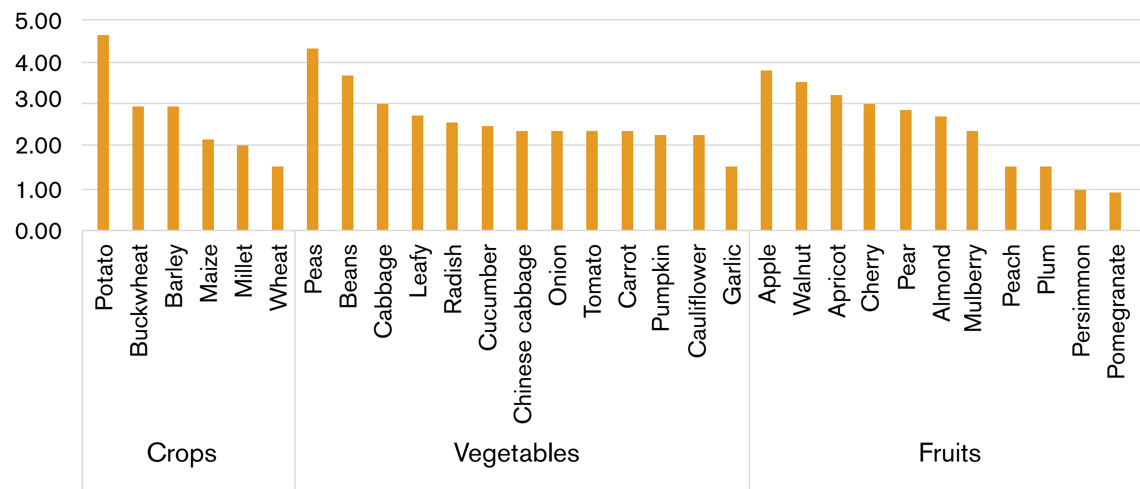


Figure 45. Crop prioritization by crop type for Cold Temperate zone (Scale 1-5 where 5 is highly recommended)



9.5. Sub Alpine Cold Temperate Zone

Potato, peas, and beans are economically viable vegetables in this zone. Barley may be cultivated successfully for self-consumption. Alternatively, if buckwheat fetches good price in national market, it may be an economically viable crop. Walnut may be a commercial fruit and bring some cash income to the farmers. **Figures 46 and 47** indicate priority of crops for this zone.

Figure 46. Crop prioritization for Sub Alpine Cold Temperate zone
(Scale 1-5 where 5 is highly recommended)

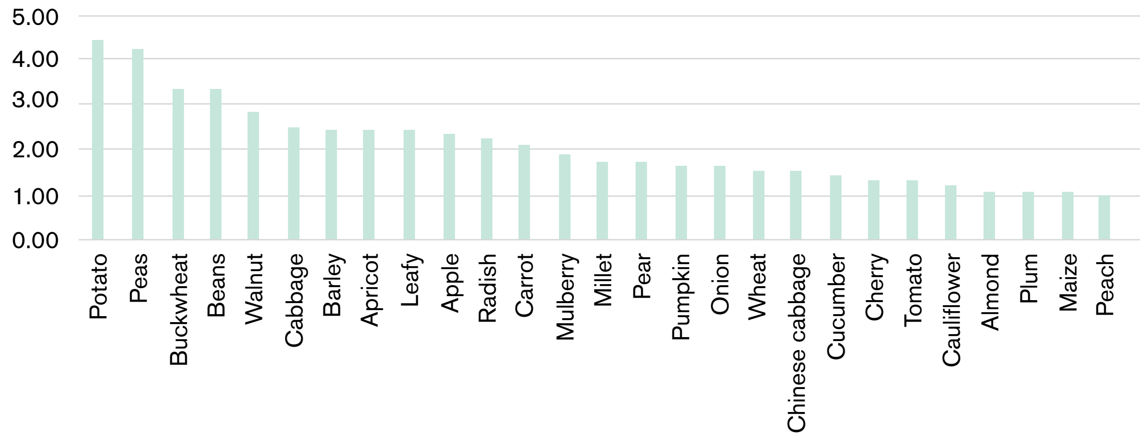
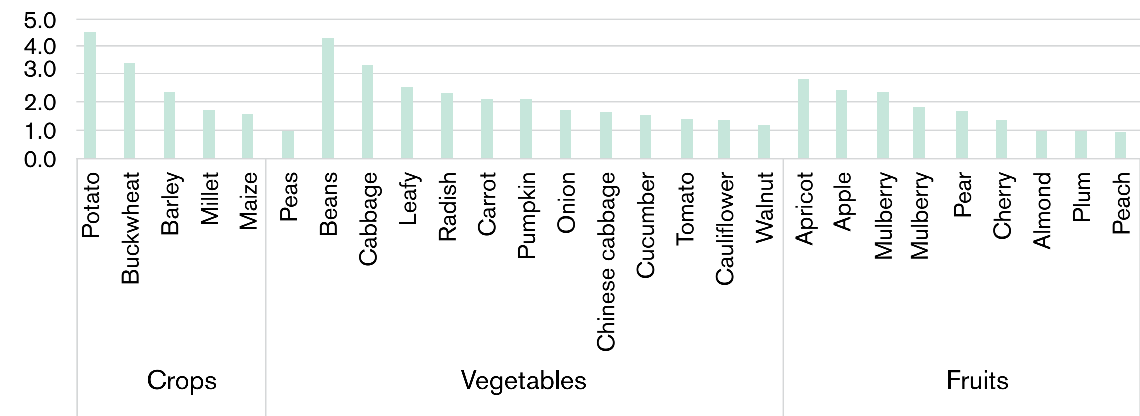


Figure 47. Crop prioritization by crop type for Sub Alpine Cold Temperate zone
(Scale 1-5 where 5 is highly recommended)



9.6. Alpine Cold Temperate zone

Most of agriculture production in this zone is for meeting subsistence needs. Potato and peas are the only two crops which may be economically profitable in this zone within the short growing period. Transportation of produce to the market, however, may be a challenge and a determining factor in deciding what to grow. This zone mainly supports livestock farming for subsistence. **Figures 48 and 49** indicate priority of crops for this zone.

9.7 High Alpine Glacial zone

This zone is located at high elevation above 12500 feet /3800 meters, and is not fit for any kind of cultivation. Lower reaches of this zone are used as summer pastures. Higher altitudes are covered by glacial reserves and mountains.

Figure 48. Crop prioritization for Alpine Cold Temperate zone
Scale 1-5, where 5 is highly recommended)

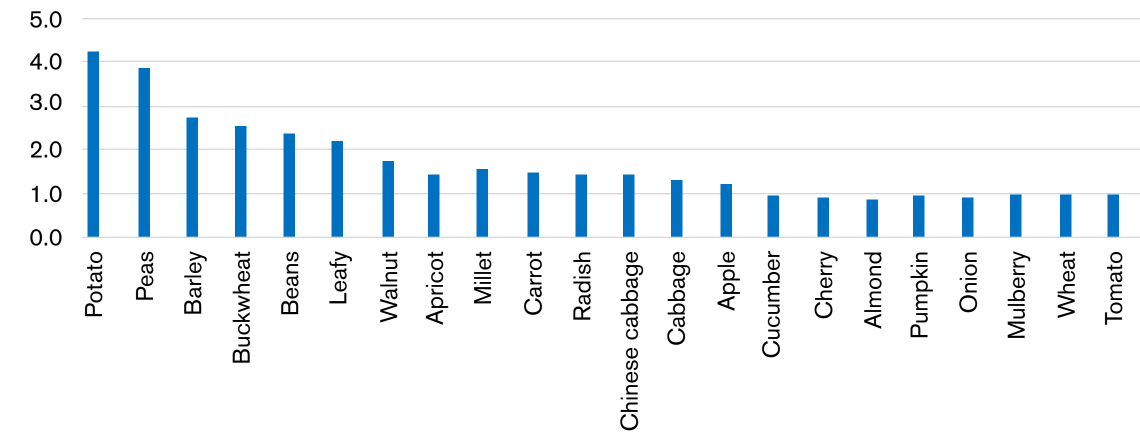
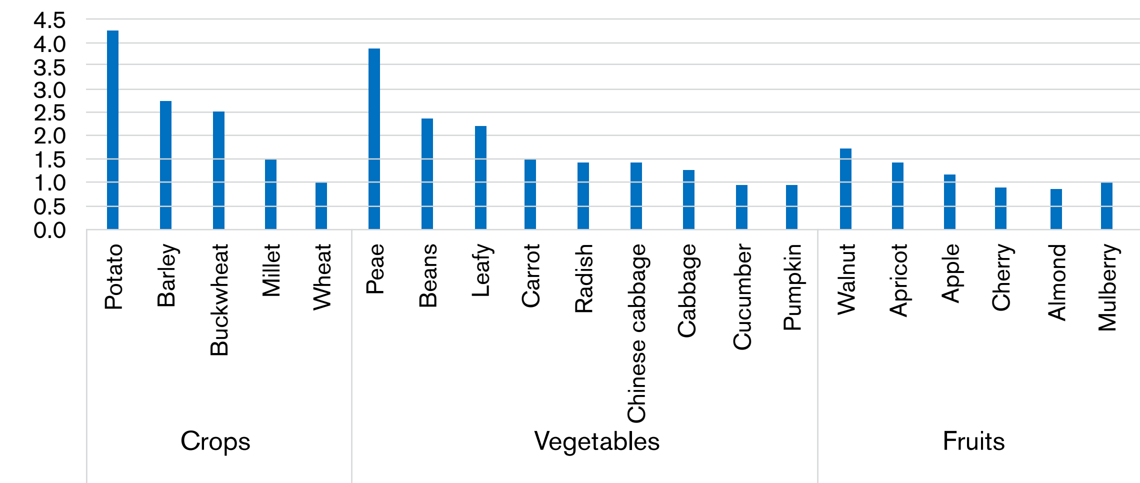


Figure 49. Crop prioritization by crop type for Alpine Cold Temperate zone
Scale 1-5, where 5 is highly recommended)



9.8. Fodder potential - all zones

Farmers in GB need to be advised to improve quality of animal nutrition. The current practices of integrating fodder in cropping system (intercropping, cultivation on peripheries) are fine, especially in lower altitudes where most fodder needs are met from crop residues (maize, wheat) in addition to small quantities produced in irrigated fields (e.g., alfalfa, berseem). On higher altitudes where livestock is the main source of livelihoods, fodder in large quantities is produced in irrigated pastures with supplement from crop residues. Fodder produced during summer is dried and stored for stallfeeding during long winters. The result of feeding less nutritious dried fodder for a long period in addition to poor housing is increased animal mortality and loss of weight. There is a high need to invest in improving quality of fodder and animal housing, especially during cold winters and high-altitude areas.

Table 9 summarizes indicative optimal cereal / vegetable production regime in various AEZs of GB. These recommendations were collected from various stakeholders (farmers, experts) with knowledge of these zones.

Table 09: Summarizes recommended optimal vegetable production regime in various zones of Gilgit Baltistan

S. No.	Crops	Cultivation method	Cultivation time												Crop duration (days)
			Zone 1 4000 – 5500 ft 1220 – 1680 m		Zone 2 5500 – 7000 ft 1680 – 2130 m		Zone 3 7000 – 8000 ft 2130 – 2440 m		Zone 4 8000 – 9500 ft 2440 – 2900 m		Zone 5 9500 – 10500 ft 2900 – 3200 m		Zone 6 10500 – 12500 ft 3200 – 3810 m		
			Sowing	Harvesting	Sowing	Harvesting	Sowing	Harvesting	Sowing	Harvesting	Sowing	Harvesting	Sowing	Harvesting	
1.	Cabbage	Transplant	July-August	Oct-Nov	June-July	Nov	April-May	Sep-Oct	Mid May	Early Sep	End May	Mid Sep			80-90
2.	Cauliflower	Transplant	July-August	Oct-Nov	May-June	Nov	April-May	Sep-Oct							90-100
3.	Peas	Seed	Feb-March	May	March	May/Jun	April-June	Oct	Apr	Aug	May	Aug	May/Jun	Aug/Sep	75-90
4.	Turnip	Seed	July-Aug	Oct-Nov	June-July	Nov	May-June	Oct-Nov	Aug	Oct					70-90
5.	Tomato	Transplant	Feb-March	June-July	March-April	Aug-Sep	April-May	Jul	May	Aug					80-90
6.	Carrot	Seed	May-July	Oct-Nov	May-June	Nov	April-May	Sep-Oct							60-70
7.	Cucumber	Seed/ Transplant	April	June-july	May	July August	May-June	July -August	May	Jul					60-70
8.	Radish	Seed	July-Aug	Oct-Nov	June-July	Nov	May-June	Sep-Oct							60-70
9.	Onion	Transplant	Feb-Mar	May/Jun	March	Jun	April	Jul	Jun	Sep					100-120
10.	Capsicum	Transplant	Jun	Aug	May – Jun	Sep-Oct									90-120
11.	Potato	Seed			Mar	Jul	Apr	Aug	Apr/May	Aug/Sep	May	Sep	May/June	Sep/Oct	100-130
12.	Wheat	Seed	Nov	May	Feb	July									140-150
13.	Maize	Seed	Jul	Oct	May/Jun	Sep/Oct	Jun	Sep/Oct	June	Oct	Jul	Oct	July	Oct	120-130
14.	Buckwheat	Seed					Mid Jul	End Aug	Aug	End Sep	Aug	Oct	Mid Jul	Mid Sep	60-70
15.	Barley	Seed					Feb/Mar	Jun	Mar	End Jun	May	Aug	Mid May	Early Sep	120-130
16.	Millet	Seed							Early Jul	End Sep					60-90
17.	Red Bean	Seed					Jul	Sep	May/Jun	Sep/Oct	Jul	Oct			120-130
18.	Okra	Seed	Mar	Jun	Mid Mar	End Jun									60-90
19.	Broad beans	Seed					Feb-Mar	Jul	Apr	Sep	Apr	Sep			90-120
20.	French Bean	Seed	Mar	May	May	Jul	June	Sep							60-70

10. Major risks and challenges in agriculture sector

Small land holding and land fragmentation:

The reason people are giving up farming and go for alternate sources of livelihoods is small land holding and poor returns. Nearly 80% households have up to 2 kanals (0.1 hectare) landholding whereas only 20% own up a maximum of 8 acres (3 hectares). Land is often distributed among siblings in smaller scattered plots. Lack of contiguity of terraces becomes labour intensive for irrigation, ploughing, harvesting and other operations. Cultivating small land does not prove economically viable, especially when vital technology decisions are involved.

Water scarcity / drought in spring:

GB is arid / semi-arid area with less than 500mm annual precipitation. Farming depends on irrigation. In areas where source of irrigation is not from perennial sources and depends on snow/glacier melt, water for irrigation is not available early in spring and later in summer/autumn. This makes the short growing season even shorter. In some areas, an innovative concept of "Glacier Farming" is being experimented to harness irrigation water in spring from farmed glaciers. Such initiatives need support of the government for experimentation and scaling up if successful.

Irrigation infrastructure to increase arable land:

Irrigation infrastructure is not available for many areas with land potentially fit for cultivation. AKRSP and the Economic Transformation Initiative (ETI) of the International Fund for Agriculture Development (IFAD) have helped communities in many areas to bring new land under irrigation. However, there is still a need for developing irrigation infrastructure to bring more land under irrigation and cultivation.

Labour intensive irrigation system:

Improved irrigation infrastructure to minimize maintenance costs for the farmers. The irrigation channels are constructed along precipitous mountain slopes. Most channels are not lined and get eroded every year due to natural hazards during snowmelt and rains. Major repair at the start of growing season and minor repairs throughout the season make the irrigation system labour intensive and un-economical to maintain. This perpetual maintenance costs may be reduced by ensuring that the structures are fully reinforced against natural hazards. New structures need to be designed by mainstreaming disaster risk mitigation.

Natural hazards (flash floods, river cutting and landslides):

The entire GB is prone to natural hazards which have increased in recent years due to climate change and climate induced variability. Human settlements, agricultural and pasture lands by the rivers are increasingly getting eroded due to unprecedented rise in volume of water in rivers during summers. River swelling is attributed to increased temperature, which causes fast melting of snow and glaciers. Disaster risk reduction and mitigation need to be fully mainstreamed in planning of all sectors (roads, agriculture, housing, hydropower). This may include exploring financial risk coverage such as crop insurance through micro-finance banks. This may not be an easy task because risks are certain, crops are generally non-lucrative and microfinance options are fewer in GB.

Absence of Integrated Crop Management (ICM):

Agriculture economies around the world have benefited from ICM, which entails management of crops in a way that reduces incidences of pests and other crop losses to increase crop productivity and economy. The crop practices in GB are still primitive and, therefore, crop losses are rather significant. Increasing prevalence of pests is reported due to increasing warming trends that disturbs the ecology of the area. ICM knowledge of extension workers and farmers need to be built at the source of the problem for timely control. A successful example in GB is the control of Mealybug which was achieved through a consistent integrated crop and pest management effort.

Absence of value addition:

GB produces many crops that can fetch high revenue with value addition. There are, however, no value addition facilities and most agricultural products are sold as raw material in the market. Post-harvest losses are prevalent in all crops, especially in fruits. Thousands of tons of fruit get wasted due to non-availability of technology and facilities for value addition.

Non-availability of quality inputs:

Quality agricultural inputs are not available in GB. Top of the list is the seed issue (wheat, potato, and vegetables seeds). There is a lack of regulatory mechanism/implementation to stop adulterated agricultural inputs. True-to-type quality fruit germ plasm is not available in the region. GB government may think of an exclusive project on improved certified seed production due to high potential for seed production in the region. Another project which merits attention is to ensure improved agro-chemicals and livestock medicines with strong regulatory mechanisms. Both these projects should be designed on public-private partnership basis.

Absence of data on soil types and soil fertility:

Establishment of a permanent facility for collection and analysis of soil data and GB soil repository. No comprehensive soil survey has been conducted for GB. Scattered data on soil types and soil fertility are not enough to provide a complete picture of soil conditions, which are diverse due to its great topographic diversity. Limited knowledge on soil results in farmers not knowing which important ingredients are missing in the soil. As a result, crop productivity in GB is quite low when compared to the rest of the county. Soil testing facilities are not available in GB. Some of the labs established with the help of short-term projects are redundant and reliance on external labs does not prove helpful. Soil needs a special focus since cultivable land is rather limited in GB and needs to be very well managed to acquire its full productive potential. The Agriculture department needs to deploy a soil survey and ensure collection, analysis, preservation, and dissemination of soil data readily possible. Establishment of a permanent soil facility however may take time. In the meantime, it is suggested that the department commissions a detailed soil survey of entire GB.

Lack of market information and storage facilities:

Promote market information and linkages with private sector. GB does not have a vibrant private sector and a large market. There is a lack of proper market information and linkages on when and where to buy quality inputs and sell products for best profits. Farmers, therefore, depend on middlemen to market their agricultural products. Storage facilities are not available to seek a chance for collective marketing at an appropriate time. Farmers are compelled to sell products as soon as the crops ripen at the farmgate or when the first buyer offers any price. They have no option to wait for better prices in the market. No doubt farmers try their best to compare rates offered by the individual middleman, most of the time the criteria for decision making are either pre acquaintance with the middlemen or sometimes acquiring advance credit from buyers. In case of fruits, usually middlemen buy fruiting trees or orchards at an early stage. In few cases, fruit is sold when near maturing stage.

Lack of suitable mechanised technology:

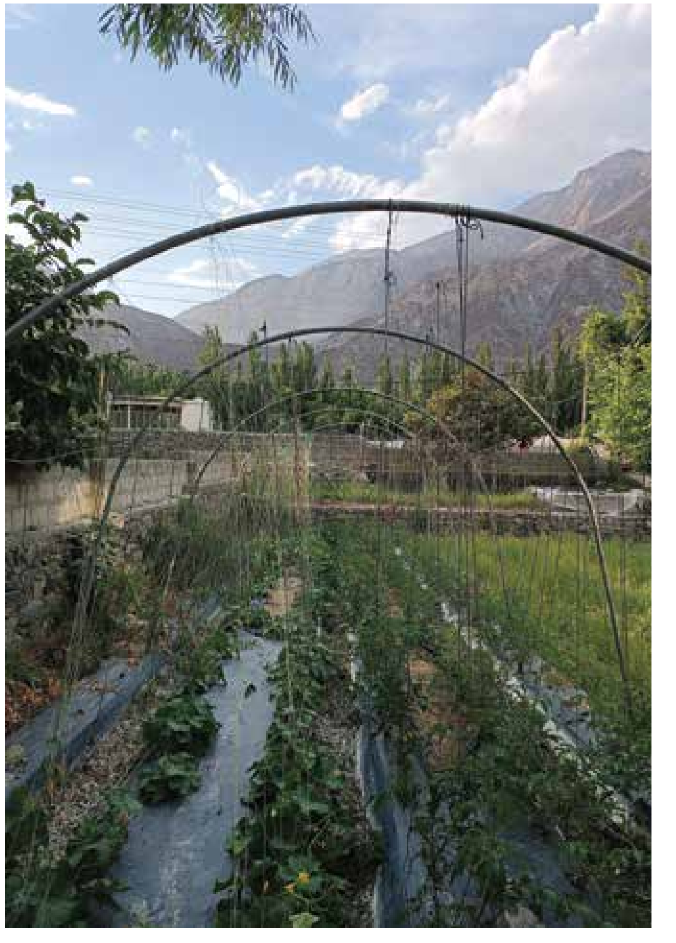
Support service provider for promotion of appropriate technology that suits the mountain terrain. Most agricultural plots are small and are located on mountain terraces. GB needs specialised mechanised technology which suits local terrain, readily available, and cost effective. Farm mechanization does not have to depend on owned machinery. Local entrepreneurs may be supported through microfinance banks to own such machinery, acquire the right skills, and offer their services as service providers. Similar models exist in KP, Punjab and Sind. The department needs to help in crafting such technologies or link with technology providers elsewhere in the country. In addition, suitable transport to carry agricultural products, especially fresh and fragile fruit, is altogether missing. This results in total loss of fresh fruit that could have reached the market.

Free grazing around agricultural lands:

The need for restricting free grazing in late summer/early autumn to grow short duration crops/vegetables. During the main crop season, animals are either taken to high pasture or stall-fed. After the harvesting of main crops in July – August, farmers use cultivable areas for free grazing by animals instead of cultivating them. This restricts cultivation of short duration second crops. This issue needs to be taken up by the GB Agriculture Extension department to advise restricting free grazing in the late summer /early autumn to give a chance to interested farmers to grow a short duration crop or vegetables. This may be achieved when a greater number of farmers are interested to grow short duration crops during late summer/early autumn window. Farmers may need to be supported for alternate sources of fodder to prevent free grazing.

Urbanization and land use change from agriculture:

Introduction of land use/housing planning to stop fragmentation of cultivated/cultivable land. Agricultural land in GB, as elsewhere in the country, is converted into housing and other concrete settlements. As a result of land fragmentation, limited land with little incentive from agriculture, and increasing population needing more space to live, agricultural terraces are converted into housing infrastructure. A pressing need for construction of houses is natural. However, the problem is caused by scattered distribution of houses since each heir/owner is compelled to build on his piece of land which then needs access through other people's terraces. This unplanned expanding settlement is changing the scarce agricultural land into scattered houses and foot paths/jeep treks. One way to manage this is to introduce housing planning in the villages and ensure that houses are constructed in compact settlement (as was the tradition) so that rural / urban facilities are easily accessible to them. Agricultural land hence will remain intact and will not be occupied by factors such as right of way or built environment. In addition, household based vertical farming may be encouraged.



Migration of young men and feminization of agriculture:

Due to small farm sizes, lack of economic return from agriculture, and tough labour engagement in the absence of mechanization, farming is not the best option of livelihoods especially for young men – both educated and otherwise. Most of them migrate to the cities in search of jobs. Farming, therefore, is increasingly the responsibility of women left behind in the villages. In many places seasonal labour coming from Kohistan is hired for agricultural related activities, especially for seasonal grass cutting, harvesting and tasks related to potato cultivation. Improved outreach of extension services in remote valleys, especially to serve women, is essential so that women may play a more productive role in agriculture.

11. Key Conclusions and recommendations

This chapter concludes findings provided in the main chapters. Since this study is mainly on AEZs & agricultural potential of GB, the findings, therefore, are mainly on this subject. However, based on additional information gathered during this assignment, findings and recommendation have also been given on the need for improvement of the agricultural practices, soils fertility and challenges faced by agriculture sector. It is important to note that the recommendations on agricultural potential are based on climatic conditions, economic aspects, and potential of bulk production for commercialisation. For subsistence, nutrition, and food security however, the farmers may grow any crop that suits their needs.

11.1 Conclusions

Agro-ecological zones, climate change and seasonality

1. This study delineates Gilgit-Baltistan (GB) into the seven Agro-ecological Zones (AEZs): Hot & Cold Temperate Zone (spread over 1.5% of the total areas of GB), Warm and Cold Temperate Zone (2%), Transitional Warm & Cold Temperate Zone (2.7%), Cold Temperate Zone (5.1%), Sub Alpine Cold Temperate Zone (4.7%), Alpine Cold Temperate Zone (14%) and High Alpine & Glacial Zone (70%).
2. Astore, Diamer, Ghizer and Gilgit Districts are spread over all seven zones. Nagar, Hunza and Skardu have six zones each whereas Ghanche, Kharmang and Shigar have five zones.
3. Topography and elevation are the most important basis for defining AEZs since these factors influence quantity and type (e.g., rainfall, snowfall) of precipitation, and temperature. The importance of PET as an indicator to defining AEZs is low because crops in GB are grown in irrigated conditions.
4. Weather patterns, particularly the temperature trends in the area have changed as witnessed in recent years. Climate change indicators are notably intense.
5. An average increase of temperature for GB from 1990 to 2020 is noted to be in the range of 0.5^{0}C to 1^{0}C. Both day (maximum) and night (minimum) temperatures are increasing, but the night temperatures are increasing at a higher rate than the day temperatures.
6. The highest increase in maximum temperature was noted in Hunza district with 2.3^{0}C in the month of March during spring season since 1990. The highest increase in minimum temperature was noted in Shigar district with 2.8^{0}C in the month of April since 1990.
7. The rate of increase in temperature is higher at higher elevations (e.g., Shigar, Ghanche) when compared to lower elevations (e.g., Diamer, Gilgit).
8. Although the temperature in GB is increasing for all the seasons, spring and autumn are registering higher increase particularly in the months of April and October as compared to winters and summers (e.g., increasing up to 2.8 ^{0}C in the months of April and October in case of Shigar).
9. Global climate scenarios 2050 place GB in the region of projected temperature increase of 1.5^{0}C to 2^{0}C between 1990 and 2050 under all climate change projection models. This means that GB will be warmer by 1.5 to 2^{0}C by 2050.
10. Due to temperature rise during spring months, the spring is starting earlier. The season also ends earlier due to early start of summer. The total shift is by 15 to 20 days. The summer season is expanding, and autumn and winter are getting shorter.
11. In most districts, precipitation is reducing in winter and spring seasons and increasing during summers and autumn. Overall precipitation in GB is projected to increase between 0 and 0.1 mm/day.

Production potential

12. Comparison of per unit area production indicates that GB is well suited for fruits, potato and vegetable cultivation and not for cereals including wheat or maize. Per unit area production of wheat and maize is significantly lower when compared to the country's average production.
13. GB's post-harvest losses are very high due lack of improved pre and post harveste handling technologies and poor infrastructure for transportation of products to the market.
14. Farmers are not fully equipped to take adaptation decisions adequately suited to new climate patterns to secure crop yields and productivity.
15. Rising temperatures, longer summers and shorter winters provide opportunities for growing longer duration crops followed by a short duration crop after the main crop is harvested. Changes in climate has made it possible to grow winter wheat in some areas where traditionally only summer wheat was cultivated.
16. Compared to 1990s, GB is increasingly connected with the market due to improved road infrastructure, digitalization, and demand for niche products having GB origin. However, remoter areas still face the challenge of access and connectivity with market.
17. Educated youth do not see much incentive in cultivating small pieces of land that they inherit. Feminisation of agriculture, therefore, is widespread throughout GB due to man power migration to other parts of the country in search of jobs and other economic opportunities. At the moment women play major role to carry out farming activities.

11.2 Recommendation

Crops and fruits suitability

1. Despite altitudinal and climatic variations across various zones, several crops are grown in multiple zones (e.g., wheat, maize, potato, cherry, apple apricot, and several vegetables). All these crops seem to grow well in different zones. The growers and decision makers must not be carried away by seeing only the ability of a crop to grow. A most important element is the economic viability of a crop in specific cropping zone. Not everything that grows in a certain zone is also economically best for that zone. It is suggested to encourage grouping of AEZs to promote bulk production of certain crops in order to meet local and national (and also international) market demand and revenue generation, for example,

    - Cherry crop may be more profitable when grown in Warm & Cold Temperate and Transitional Warm & Cold temperate zones, although it can also grow in Cold Temperate Zone. It is suggested to promote cherry in the two zones where it is more profitable.
    - Potato is grown in all six zones whereas it has a far better performance in cold-

er zones (Transitional Warm & Cold Temperate, Cold Temperate, and Sub alpine Cold Temperate zones).
- Tomato and cucumber perform well in three zones – Hot & Cold, Warm & Cold, and Transitional Warm & Cold Temperate zones, particularly in vertical farming mode.

2. Wheat should be only promoted as a rotational crop with potato and other high value vegetable crops. GB's climate and scarce agricultural land are suitable for growing high value crops than wheat and maize.
3. For grouping zones and prioritizing crops (based on the potential of various AEZs), a workshop of the officials of the agriculture department across GB supported by external experts is strongly recommended. This exercise should build on indicative prioritization documented in this report and take final decisions on promoting crops, fruits and vegetables for each zone for bulk production to meet local, national and possibly international demand.

Managing production challenges

4. The entire GB is prone to natural hazards which have increased in recent years due to climate change and climate induced variability. Financial risk coverage for economically high value crops may be piloted through insurance schemes.
5. Increasing prevalence of pests and disease have been reported due to increasing warming trends that disturbs the ecology of the area. ICM knowledge of extension workers and farmers need to be built for timely control of the problem at the source.
6. Post-harvest losses may be minimised by introducing value addition, developing cold supply chains and crop storage facilities.
7. Quality and timely provision of seed and true-to-type quality planting material are lacking in GB. An exclusive project on improved certified seed / planting material production is necessary in the region.
8. Another project which merits attention is to ensure quality agro-inputs with strong regulatory mechanisms. Both these projects should be designed on public-private partnership basis to acquire quality and competitiveness in products.
9. In order to make best use of the extended cropping windows, it is necessary to aware farmers to revisit grazing system to prevent open grazing during early spring/late autumn to promote short duration crops.
10. Scaling up of vertical farming for optimal resource uses, avoiding harvest losses and to maximize per unit area production is suggested throughout GB.
11. In areas with no perennial irrigation water source, shortage of irrigation water in spring and autumn is common. This makes the short growing season even shorter. To overcome this challenge, developing irrigation sources including Glacier Farming or other innovations needs investigation and promotion.
12. The perpetual maintenance costs of irrigation infrastructure may be reduced by ensuring that the structures are reinforced against natural hazards. New structures need to be designed on disaster resilience principals.

Loss of agriculture land and soil erosion

13. With increasing population growth, development and urbanization, agricultural land in converted into houses, markets, roads and footpaths etc. One way to manage loss of agricultural land to scattered housing and related infrastructure (e.g., right of way to scattered houses within the agricultural fields in the villages), is to introduce housing planning in the villages and ensure that houses are constructed in compact settlement, as was the tradition throughout GB.
14. Soil analysis indicate that the soils in GB are poor in organic matter which need to be addressed. Among others, improving irrigation practices to conserve soil is imperative.
15. Establishment of a permanent facility for collection and analysis of soil data and GB soil repository is necessary.

Commercialising, extension support, and farm machinery

16. It is suggested that the government promotes commercialization of agriculture by supporting cultivation of key commercial crops and facilities for processing and packaging. Commercialisation of agriculture will provide incentives for youth especially those educated to return to the agriculture sector. Supporting interest groups and individuals on competitive bases will encourage development of agriculture-based enterprises.
17. Food security is another important issue that the government has to prioritize in the policies. Food security, however, cannot be achieved by simply encouraging cultivation of wheat and maize. It is a well-established fact that GB was never self-sufficient in grain even when the population was very small and only subsistence crops including wheat and maize were grown. That was the reason that the government started supplying subsidized wheat some 40 years ago. In case subsidy on wheat is withdrawn, the government must have an alternate strategy to fill the gap for food security. Encouraging farmers to cultivate wheat and maize will not serve the purpose. Growing high value crops in the limited cultivable land for higher income and buying grains from the open market may be an option for food security in the long run.
18. Promoting market information and linkages with private sector must be further encouraged. Storage facilities may be established with private sector support to utilize opportunity for collective marketing at an appropriate time where applicable.
19. GB needs specialised farm mechanisation technology that suits local terrain, is readily available, and is cost effective. Local entrepreneurs may be supported through microfinance banks to own such machinery, acquire the right set of skillset, and offer services. This will fill service gaps and provide jobs.
20. Improved outreach of extension services in remote valleys, especially to serve women, is essential so that women may play a more productive role in agriculture and overcome malnutrition issues This becomes even more important in the wake of feminization of agriculture in GB.

Research

21. Pest monitoring research to identify the pest activities in different AEZs to understand the impacts of climate change on the population of pests.
22. Establish observation points in each AEZ to monitor sprouting shifts due to climate change to help selection of suitable varieties, especially fruits.
23. Based on existing and climate change knowledge identify appropriate varieties of crops and fruits suitable for each zone.
24. An extensive soil survey may be deployed to form a baseline and ensure collection, analysis, preservation, and dissemination of soil data readily.
25. Document indigenous knowledge and practices on selected crops and fruits cultivation, post-harvest management, and food preservation.

Agro-Ecological Zones profiles of individual districts

Agro-Ecological Zones

Astore

Latitude 35.3570° N and Longitude 74.8624° E

1. Introduction

District Astore is spread over an area of 5,411 sq.km (541,100 hectares) which is 7% of the total area of Gilgit-Baltistan (GB)[1]. Astore District is bounded by Gilgit district to the north, Skardu district to the east and Diamer district to the west. The district headquarter is Eidgah town. The district is located at an average elevation of over 2591 meters (m). Tourists' hotspots of Astore are Rama Lake, Rainbow Lake, Deosai plains and Deosai Lake, Nanga Parbat, and Kala Pani. Astore shares Deosai plains with districts Skardu and Kharmang. Administratively Astore district is divided into two tehsils: Astore and Shounter. The population of district Astore in 2017 was 100,000 with 11,236 households at an average household size of 8.9[2] in 46 villages[3]. With a growth rate of 1.77[4], the estimated population of Astore in 2022 was 109,169 persons. The overall literacy rate in the district is 50% (male literacy 69% and female 44%)[5]

2. Land use statistics

According to the Agriculture Department GB, the total agricultural land of the district is 11,844 hectares (ha). Out of which 4,365 ha is cultivated while 7,479 ha is cultivable waste[6]. The land use statistics of district are given in **Table 1.**

Table 1. Land use statistics

S.No.	Type of Land	Area (Ha)	Percentage
1.	Agricultural Land	11,844	2.2%
2.	Forest Land	31,774	5.9%
3.	Range Land & Pastures	235,218	43.5%
4.	Rivers/Lakes	16,591	3%
5.	Built up Area	649	0.2%
6.	Snow/Glaciers	54,035	10%
7.	Rocks	142,024	26%
8.	Unaccounted for	48,966	9%
	Total	**541,100**	**100%**

Source: Calculated using GIS tools based on district shape files provided by GB Agriculture department 2022

3. Current features of agriculture

The crops grown and cropping pattern in Astore is influenced by elevation which ranges from about 1219 m to 3658 m. The lower parts of the district (e.g., Bunji) fall in double cropping system while the upper parts fall in single cropping system. The major cereal crops of the district are wheat, maize and barley. The vegetables grown are potato, peas, tomato, cucumber, Chinese cabbage, radish, carrot, pumpkin, onion and beans. The major fruits of the district are apricot, apple, mulberry, pear, persimmon, grape, peach, plum walnut and almond. Fodder is also produced in sufficient quantity. It is important to note that farmers grow mix crops for subsistence in the same season. The typical cropping pattern followed in district Astore is given in **Table 2.**

Table 2. Current cropping pattern

Altitude (m) and major locations (examples)	Cropping Pattern
Altitude: Below 1830 **Cropping season:** Feb – Nov Double cropping **Major locations:** Bunji	• Wheat followed by maize. • Vegetables are grown parallel to the crops on small pieces of land or intercropped. • Fodder as irrigated perineal crop. • Fruits: Apricot, apple, mulberry, pear, peach, plum, walnut and almond, pomegranate and persimmon
Altitude: 1830 to below 2135 **Cropping season:** Mar – Sep Single cropping **Major locations:** Doyan, Dashkin, Harcho	• Wheat followed by leafy vegetables or fodder – OR • Potato followed by leafy vegetables or fodder • Vegetables are grown parallel to the crops on small pieces of land or intercropped • Fodder also grown as irrigated perineal crop. • Fruits: Apricot, apple, mulberry, pear, peach, plum, walnut and almond
Altitude: 2135 to 2440 **Cropping season:** April – Sep Single cropping **Major locations** Bulan, Gorikot, Makial, Pakora, Kushinat, Chongra, Dashkin Bala	• Wheat or maize OR • Potato – fallow • Vegetables are grown in limited quantities, parallel to the crops on small pieces of land or intercropped. • Fodder is grown as irrigated perineal crop. • Fruits: apricot, apple, mulberry, pear, peach, plum, and walnut
Altitude: 2440 to 2900 **Cropping season:** May – Sep Single cropping **Major locations:** Khomay, Gudai, Rattu, Tarishing, Nowgam, Aigah, Yagam, Parishing, Dirlay, Ispay	• Wheat – fallow, OR • Potato – fallow • Vegetables are grown in limited quantities, parallel to the crops on small pieces of land or intercropped. • Fodder is grown as irrigated perineal crop. • Fruits in limited quantities: apple, apricot and walnut
Altitude: 2900 and above **Cropping season:** 15th May – Sep Single cropping **Major locations:** Chilim, Minimarg, Dodhgai, Qamri, Mir Malik, Gutum Sir	• Barley – fallow, OR • Potato – fallow • Vegetables are grown in limited quantities side by side the crops. • Fodder is grown as irrigated perineal crop. • Fruits are rare

Source: Primary data from district workshops and interviews

[1] GB at a glance 2020. Government of Gilgit Baltistan
[2] Ibid
[3] Agriculture Statistics Report 2014. Gilgit Baltistan
[4] https://www.citypopulation.de/en/pakistan/cities/gilgitbaltistan
[5] GB at a Glance 2020. Government of Gilgit Baltistan
[6] Agriculture Census 2020, department of Agriculture Gilgit Baltistan

4. Soil characteristics

Soil characteristics of Astore are dominated by parent material. Most of the parent material is Lithosols, which is characterised by coarse textured un-weathered or partly weathered rock fragments, usually found on steep slopes. Soils are generally shallow. Lithosols are highly prone to land degradation and cannot support sustainable crop production without strong efforts for conservation. If this shallow soil is lost, it will be a long weathering process before new soil is formed. Gleysols is located on shared borders with Diamer with slightly acidic to neutral pH. Similarly, a very small pocket of Cambisol with highly fertile characteristics is found in areas bordering Skardu. Sandy loam is dominant soil texture in Astore. Summary of soil characteristics is provided in **Table 3**.

Table 3. Summary of soil characteristics

Parent material	Organic Matter (%)	Fertility			Soil texture		pH
		NO3-N (mg kg^{-1})	P (mg kg^{-1})	K (mg kg^{-1})			
Lithosols 88% Gleysols 10% Eutric Cambisol 2%	Adequate	Low	Low	Adequate	Sandy loam 80%	Silt loam 20%	Slightly acidic to neutral below 2135 meters. Neutral to slightly alkaline above 2135 meters

5. Climate trend

Overall, the increase in temperature between 1991-2020 is higher than the increase between 1960-1990. Since 1991 the daytime temperatures have increased by 0.6°C while the night temperatures have increased by 1.3°C. The nights are becoming warmer in every season. The maximum temperature has increased in springs followed by autumn and summers. This means that the highest increase in daytime temperature is noted in the spring season.

The annual precipitation had slightly increased after 1960 till 1990. It declined after 1991 although still more precipitation is received than in 1960. Precipitation trends have also shifted. More precipitation is received in winters and summers whereas precipitation in spring has declined. Overall precipitation is expected to remain the same in the future, but spring will be drier than before, and summers will be wetter. Therefore, the springs season will be warmer and drier resulting in early glaciers/snowmelt.

The following sub sections provide details on day and night temperatures (**Tables 4 and 5**), and precipitation (**Table 6**). These analyses are based on average conditions. There may be year to year variations (e.g., cold wave during spring, or wetter than average or drier than average). This climate variability is not accounted for in ascertaining climate change trend.

5.1 Analysis of maximum temperature

- Mean monthly day time temperatures during winter months, except in December, have consistently increased over the last 30 years. Temperatures during daytime in December are slightly decreasing.
- Day temperatures in spring season are also increasing. The largest increase of around 2°C is noted in the months of March and April.
- Summers daytime temperatures are also rising by 0.5°C for almost all the months. It is important to note that temperatures for June, July and August were declining between 1960-1990 and the situation reversed since 1991.
- Autumn daytime temperatures are increasing for October and decreasing in November.

Table 4. Trend analysis of mean monthly maximum temperature (°C)

	1960-2020			1960-1990			1991-2020		
Months	Change from - to	Change in temperature	Trend	Change from - to	Change in temperature	Trend	Change from - to	Change in temperature	Trend
Dec	-2.5 to -1.9	0.6	↑	-2.7 to -2	0.7	↑	-1.7 to -2.2	-0.5	↓
Jan	-5.2 to -5.2	0	↔	-5.6 to -4.8	0.8	↑	-5.7 to -5	0.7	↑
Feb	-4.3 to -3.1	1.2	↑	-4.1 to -4.1	0	↔	-3.4 to -3.2	0.2	↑
Mar	1.1 to 2.5	1.4	↑	2 to 0.8	1.2	↓	1.2 to 3.2	2	↑
Apr	6.7 to 7.2	0.5	↑	6.8 to 7.6	0.8	↑	6.8 to 8.7	1.9	↑
May	10.4 to 11.5	1.1	↑	10.4 to 11.1	0.7	↑	10.7 to 11.7	1	↑
Jun	15.8 to 15.2	-0.6	↑	16 to 15.2	-0.8	↓	15 to 15.5	0.5	↑
Jul	18.6 to 18.6	0	↔	18.7 to 18.6	-0.1	↓	18.4 to 18.8	0.4	↑
Aug	18.3 to 17.9	-0.4	↑	18.3 to 18.1	-0.2	↓	17.9 to 18.1	0.2	↑
Sep	15.4 to 15.6	0.2	↑	15.2 to 15.8	0.6	↑	15.2 to 15.7	0.5	↑
Oct	9.7 to 10.3	0.6	↑	10 to 9.7	-0.3	↓	9.5 to 10.8	1.3	↑
Nov	3.1 to 4.3	1.2	↑	2.8 to 3.9	1.1	↑	4.2 to 3.9	-0.3	↓

5.2 Analysis of minimum temperature

- Since 1960 (base year), the night temperatures during winters are on the rise. Mean monthly night-time temperatures in winter have increased in the last 30 years, however decreased in December by 0.4°C.
- Night temperatures in spring are increasing. The highest increase is noted in April. The springs are becoming warmer since both the day and night temperatures are increasing which may allow early sowing of crops. The increasing temperature may also result in fast snow melt and flash floods.

- Night-time temperatures in the summer months showed a decreasing trend during the period 1960 - 1990 and increasing trend during the period 1991-2020. The highest increase is noted in September.
- As in case of other seasons, warming trend is also observed in autumn with the highest increase noted in October during 1991-2020.

Table 5. Trend analysis of mean monthly minimum temperature (°C)

	1960-2020			1960-1990			1991-2020		
Months	Change from - to	Change in temperature	Trend	Change from - to	Change in temperature	Trend	Change from - to	Change in temperature	Trend
Dec	-12.2 to -10.5	1.7	↑	-12.7 to -10.9	1.8	↑	-10.7 to -11.1	-0.4	↓
Jan	-14.7 to -13.5	1.2	↑	-15 to -13.6	1.4	↑	-14.1 to -13.6	0.5	↑
Feb	-13.6 to -12.1	1.5	↑	-13.2 to -13.5	-0.3	↓	-12.7 to -12.1	0.6	↑
Mar	-8.8 to -6.8	2	↑	-8.2 to -8.4	-0.2	↓	-8.2 to -6.2	2	↑
Apr	-4.1 to -2	2.1	↑	-3.8 to -3.2	0.6	↑	-3.8 to -1.4	2.4	↑
May	-1.6 to 0.6	1	↑	-1.4 to -0.5	0.9	↑	-0.8 to 0.8	1.6	↑
Jun	3.3 to 4.1	0.8	↑	3.8 to 3.1	-0.7	↓	3.3 to 4.5	1.2	↑
Jul	6.3 to 7.2	0.9	↑	6.7 to 6.3	-0.4	↓	6.3 to 7.7	1.4	↑
Aug	5.9 to 6.9	1	↑	6.3 to 6.1	-0.2	↓	5.9 to 7.5	1.6	↑
Sep	1.7 to 3	1.3	↑	2.2 to 1.9	-0.3	↓	1.8 to 3.5	1.7	↑
Oct	-3.7 to -1.2	2.5	↑	-3 to -3.3	-0.3	↓	-3.5 to -1.1	2.4	↑
Nov	-8.6 to -7.2	1.4	↑	-8.6 to -7.8	0.8	↑	-8.1 to -7.1	1	↑

5.3 Analysis of precipitation

Annual precipitation has increased since 1960 but this increase was mainly noted between 1960-1990. It started declining since 1991. An increase in precipitation is noted in summers and winters. March, April and May becoming drier with reduced rainfall. Rains in the month of May are shifting towards June. Further details are as follows:

- More precipitation is received as rainfall than snow – this is the change observed since 1991.
- Against the base year of 1960, winter precipitation shows an increasing trend. A major increase was noted in the period 1960-1990. A slight decline in the precipitation trend is observed since 1991.
- Spring precipitation is declining since 1960 and shifting towards summers. This reduction is observed more in the month of May.
- Precipitation is increasing in summer since 1960. This increasing trend has, however, started slowing down since 1991. The precipitation is increasing in the months of June, July and August. The maximum increase is noted in June whereas in September no change is observed since 1960.
- In autumn, the trend is slightly on increasing side against the base year 1960. There was more increase during the period 1960-1990. This increase is observed in the month of November.

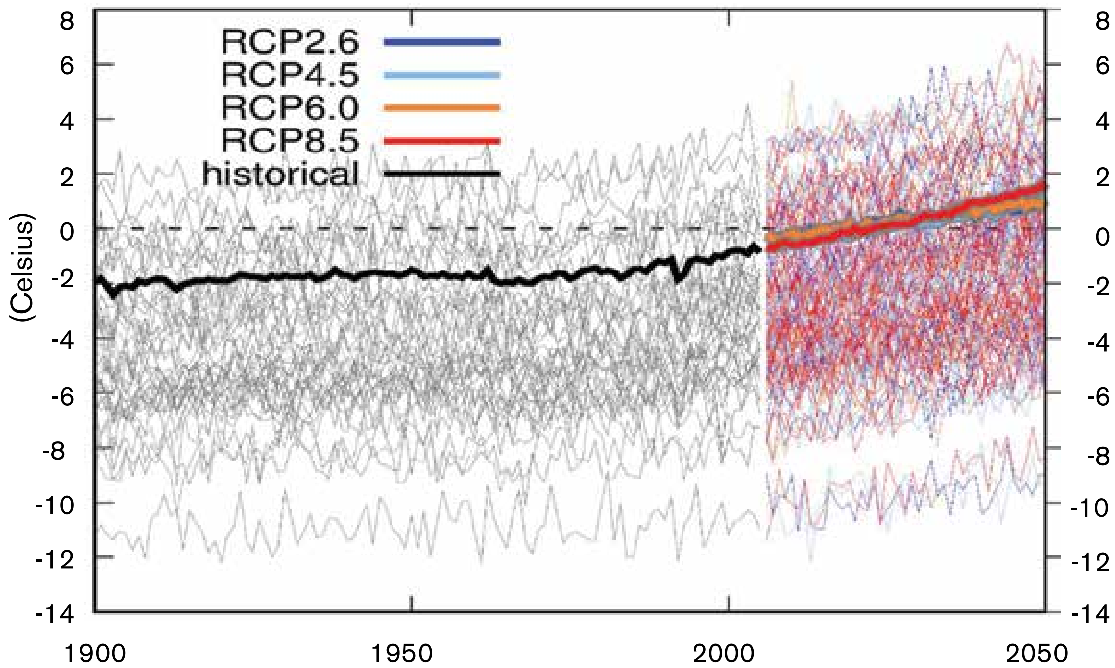
Table 6. Trend analysis of annual and seasonal precipitation (mm)

	1960-2020			1960-1990			1991-2020		
Season	Change from - to	Change in precipitation	Trend	Change from - to	Change in precipitation	Trend	Change from - to	Change in precipitation	Trend
Annual	415 -445	30	↑	390 - 460	70	↑	444 – 428	-16	↓
Winter	98 -116	18	↑	92 - 114	22	↑	112 - 110	-2	↓
Spring	162 - 144	-18	↓	160 - 156	-4	↓	154 - 142	-12	↓
Summer	120 - 154	34	↑	110 - 150	40	↑	150 - 142	-8	↑
Autumn	32 - 35	3	↑	30 - 42	12	↑	27 - 34	7	↑

5.4 Climate scenarios

Figure 1 is based on near surface annual average temperatures since 1900 and presents a projection till 2050. This projection is based on four emissions scenarios and how emissions will affect the temperature in Astore. Taking the historical trend from 1900 time series given in **Figure 1** predicts that under different scenarios the mean annual temperature of Astore will be between 1°C and 2°C which at the turn of the century was -2°C. This will be a rise of 3°C to 4°C since 1900.

Figure 1. Temperature projection till 2050



Source: IPCC Assessment Report 5 – 2014

To adapt to these changes, farmers will need to have enhanced access to irrigation facilities to tend crops more reliably. The early snow melt may cause flash floods. There could be more water in water sources (rivers, streams) in spring due to rise in temperature and early snow melt. The growing season may prolong due to warmer springs and autumns.

6. Agro-ecological zones

All seven AEZs classified for GB prevail in Astore. This can be a management challenge as well as an opportunity for agricultural diversity. **Figure 2** presents AEZs map of Astore and **Table 7** provides details of major locations falling in various zones and characteristics of zones. **Figure 3** presents percentage of each zone prevalent in the district. **Table 8** provides potential of crops in respective AEZs.

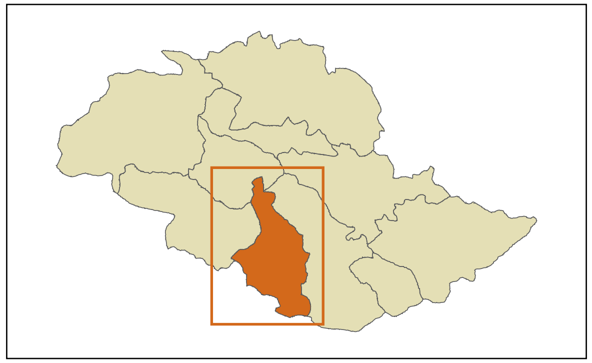


Figure 2. Agroecological zones of Astore District

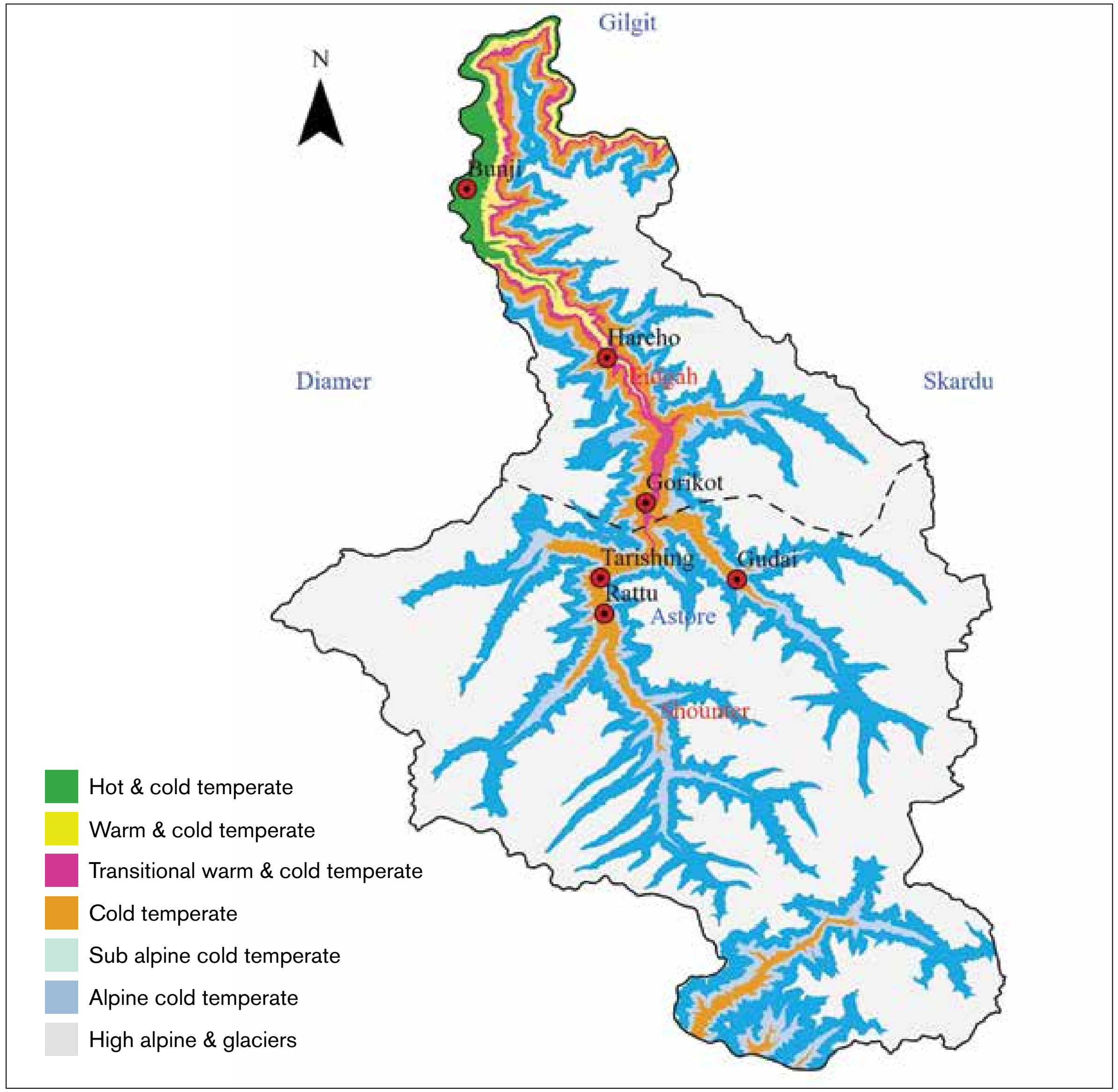
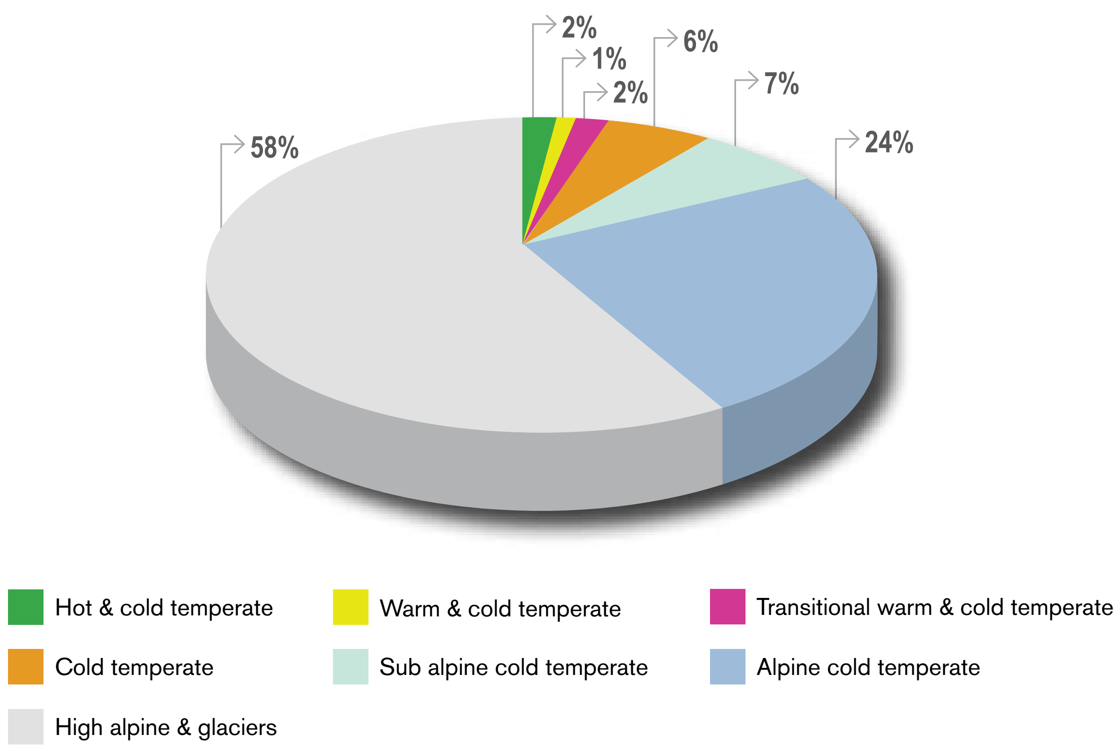


Table 7. Major locations falling in various AEZs

Agro-ecological zones	Major locations
Hot & Cold Temperate Alleviation: 4,000-5,500 feet (1,220-1,720 m) Avg. Temp.: 4.5°C Avg. Prec.: 427 mm	This zone is a small stretch adjoining district Diamer comprising Bunji in Astore tehsil.
Warm & Cold Temperate Alleviation: 5,500-7,000 feet (1,720-2,150 m) Avg. Temp.: 4.4°C Avg. Prec.: 389 mm	Adjoining with Bunji area, this zone includes lower Doyan, lower Dashkin and Harcho areas. It is also located in Astore tehsil.
Transitional Warm & Cold Temperate Alleviation: 7,000-8,000 feet (2,150-2,450 m) Avg. Temp.: 3.9°C Avg. Prec.: 419 mm	This is another thin but compact stretch, mainly including Shogrot, Hapuk, Datch, Lous, Fina, Bulan, Eidgah, Gorikot. This zone is located in Astore tehsil.
Cold Temperate Alleviation: 8,000-9,500 feet (2,450-2,900 m) Avg. Temp.: 3.2°C Avg. Prec.: 441 mm	A larger part of this zone is located in Shounter tehsil. Locations include Makial, Pakora, Kushinat, Zail, Khomay, Gudai, Rehmanpur, Chorit, Zaipur, Tarishing, Chowgam, Dashkin Bala, Mushkin, Doyan Bala Choungra, Sheype, Palyat, Mushkay, Dodugai, Ziyan
Sub Alpine Cold Temperate Alleviation: 9,500-10,500 feet (2,900-3,200 m) Avg. Temp.: -3.5°C Avg. Prec.: 339 mm	A larger part of this zone is located in Shounter tehsil. Locations include Nasirabad, Kulalot, Rattu, Dadojail, Chaien, Gorial Jutte, Faqirkot, Rupal, Nowgam, Aigah, Yagam, Kharbay, Dirlay, Ispay, Shankar Gardh, Sakamal.
Alpine Cold Temperate Alleviation: 10,500-12,500 feet (3,200-3,800 m) Avg. Temp.: -4.0°C Avg. Prec.: 259 mm	A larger part of this zone is located in Shounter tehsil. Locations include Chilim, Minimarg, Kamri, Mir Malik, Thing Payan & Bala, Gutum Sir, Chiti Nadi, Gishat, Kalshai, Tetwal, Grat Nallah, Guzair
High Alpine and Glaciers Alleviation: 12,500 feet + (3,800 m +) Avg. Temp.: -7.1°C Avg. Prec.: 227 mm	This is an area which is only used as high-altitude pastures and not for crops.

Figure 3. Percentage area under various AEZs



7. Agricultural potential

In an irrigated agriculture system with 4-5 months of summer, most crops may be grown in most of the zones except for the Alpine Cold Temperate zone where fruits and wheat do not ripe due to short growing season. However, some crops grow well in some zones compared to others. The recommendations therefore are based on what could grow well giving best yields, and not on which crops are grown at present. In addition to introducing an appropriate cropping pattern, soil fertility management and erosion control are imperative. The following potential has been identified in consultations with Agriculture Department and farming community as well as considering market potential (**Table 8**).

Table 8. Potential of crops in various AEZs

Type	Potential crops	Remarks
Potential in Hot & Cold Temperate zone		
Cereals	Wheat (winter sowing), Maize,	Maize hybrid is a priority in this zone. Winter wheat is a second priority and is recommended to be sown for subsistence and to contribute to self-sufficiency of GB in wheat grain. Wheat grown in winter does not compete with other crops. Farmers reported that availability of wheat seed is a challenge and needs to be arranged on timely basis.
Vegetables	Capsicum, tomato (indeterminate)	Capsicum and tomato with multiple pickings have potential. Tomato has a season advantage with early variety and product arrives when tomato is in short supply in GB as well in the rest of Pakistan. Cucumber, onion, and garlic are other suitable vegetables. Vertical farming tunnels are strongly recommended for cucumber and other suitable vegetables for greater benefit.
Fruit	Pomegranate, persimmon	Top priority fruits in this zone are pomegranate and persimmon. Persimmon has a high demand in down country. Beside these, apple, cherry, and grapes are also cultivated and can be enhanced with varietal improvement.
Fodder	Trifolium / Shaftal / Berseem Alfalfa (imported varieties)	Trifolium is cultivated in the field and is also intercropped while Alfalfa is grown in irrigated land as perennial crop.
Potential in Warm & Cold Temperate zone		
Cereals	Wheat (winter sowing), Maize,	Maize is a priority in this zone. Winter wheat is a second priority cereal and is recommended to be sown for subsistence and to contribute to self-sufficiency of GB in wheat grain. Winter wheat does not compete with other crops. Farmers reported that availability of wheat seed is a challenge and needs to be arranged on timely basis.
Vegetables	Potato, cucumber	Potato is sown earlier and, therefore, the production arrives earlier, which receives comparative advantage in the market due. Capsicum is also highly economic crop with high market demand. Cucumber may be cultivated in vertical farming tunnels along with other vegetables suited to vertical farming including tomato.
Fruit	Apple, walnut and berries	Top priority fruits in this zone are apple followed by walnut. Other fruits may include cherry, almond, grapes, apricot, and berries. Berries of different kinds (e.g., raspberry, blackberry) is suitable due to slightly acidic soils in this zone.
Fodder	Trifolium / Shaftal / Berseem Alfalfa	Trifolium is cultivated separately as well as intercropped with orchards and maize while alfalfa as perennial crop in irrigated land
Potential in Transitional Warm & Cold Temperate zone		
Cereals	Wheat (winter sowing only), buckwheat	Wheat is cultivated in spring in this zone which must shift to winter. Interested farmers will need support for arrangement of seed. This will make limited agricultural lands available for other high value crops in summer. Potentially barley (good fodder) and buckwheat are good choice for this zone, particularly due to historical tradition of buckwheat. Winter wheat may be followed by barley-buckwheat and/or vegetables. Alternatively, potato may be cultivated after wheat.

Vegetables	Potato, cucumber, pulses	Farmers may decide to either grow winter wheat or leave the land fallow during winter for cultivating potato in the spring. Potato harvesting may follow short duration vegetables e.g., broad beans. Tomato and cucumber are strongly suggested to be cultivated in vertical farming tunnels for greater benefit. Intercropping with cabbage or Chinese cabbage may increase per unit area production and cash return.
Fruit	Apple, walnut, cherry	Apple and walnut are already flourishing in this zone. However, cherry may be a high potential due to seasonal advantage in transitional warm & cold temperate zone since the crop arrives after cherry from lower altitude areas is no more available in the market. Other fruits include mulberry, apricot, pear, and peach (along with pine nuts as wild product).
Fodder	Barley / millet Alfalfa	Barley and millet cultivated separately as well as intercropped with orchards and maize while alfalfa in irrigated pasture as perennial crop
Potential in Cold Temperate zone		
Cereals	Barley, Buckwheat	Currently the farmers grow spring wheat for subsistence which should be discouraged because it occupies limited high value agricultural lands suited for better alternate crops - barley followed by buckwheat or barley followed by vegetables for cash. There is an increasing demand for buckwheat in the national market.
Vegetables	Potato, Peas, turnip, cabbage	Potato and peas are the most viable cash crops in this zone. Turnip and cabbage may be short duration crops for cash and home consumption. In addition, broad beans give excellent production in this zone and must be encouraged (a crop which was well-known in Astore in the past).
Fruit	Apple, walnut, apricot	Apple arriving after apple from lower altitude areas not available on the market can fetch good price. Walnut as a niche and apricot as potential niche are three fruit crops suitable for this zone.
Fodder	Irrigated and natural pastures and crop by-products	Perineal grasses are produced on large scale on irrigated pastures
Potential in Sub Alpine Cold Temperate zone		
Cereals	Barley, Buckwheat,	Traditionally, farmers in this zone used to cultivate buckwheat and millet for self-consumption. Alternate to buckwheat is barley and spring wheat.
Vegetables	Potato & Peas	Potato and Peas are most viable cash crops in this zone. In addition, broad beans, turnip are suited due to high local demand for self-consumption.
Fruit	Walnut, apple, apricot	Apple may receive a seasonal advantage in this zone. Raspberry is suitable here and has been proven from recent experiments.
Fodder	Perineal grasses, natural pastures and crop by-products	Perineal grasses are produced on large scale on irrigated pastures.
Potential in Alpine Cold Temperate zone		
Cereals	Barley, buckwheat	The growing season in this zone is barely enough for short duration crops of barley or buckwheat.
Vegetables	Potato, peas	Potato remains a cash crop in this zone and competes with cereal crop in terms of cultivation season.
Fruit	Berries	Not suited for conventional fruit crops, but suitable for berries.
Fodder	Natural pastures and crop by-products	Perineal grasses are produced on large scale on irrigated pastures.

Agro-Ecological Zones

Diamer

Latitude 35.4381° N and Longitude 73.9360° E

1. Introduction

District Diamer is spread over an area of 7,234 sq.km (723,400 Ha) which is 10% of the total area of Gilgit-Baltistan (GB)[1]. The district is bounded by Astore district in the east, Upper Kohistan district of the Khyber Pakhtunkhwa in the south-west, the Ghizer district in the north & north-west, and the Gilgit district in the north & northeast. The district headquarter is the town of Chilas. The district starts from an elevation of 1,250 meters (m) to above 3,000 m. Administratively, Diamer district is composed of three tehsils, namely Chilas, Darel and Tangir. The total population of the district in 2017 was 270,000 with 33,333 households at an average household size of 8.1[2] dwelling in 155[3] villages. With a growth rate of 3.83[4], the estimated population of the district in 2022 is 325,820 persons. This is the highest population growth recorded in GB. The overall literacy rate is 29% - male 50%, female 11%[5], the lowest in GB.

2. Land use statistics

According to Agriculture Department GB, the total agricultural land of the district is 10,747 hectares (ha). Out of which 5,503 ha is cultivated while 5,247 ha is cultivable waste[6]. Land use statistics of Diamer (2022) are given in **Table 1.**

Table 1. Land use statistics

S.No.	Type of Land	Area (Ha)	Percentage
1.	Agricultural Land	10,774	1.5%
2.	Forest Land	163,853	22.7%
3.	Range Land & Pastures	284,116	39.3%
4.	Rivers/Lakes	25,515	3.5%
5.	Built up Area	1302	0.2%
6.	Snow/Glaciers	38,394	5.3%
7.	Rocks	199,447	27.5%
	Total	**723,400**	**100%**

Source: Calculated using GIS tools based on district shape files provided by GB Agriculture department 2022

3. Current features of agriculture

The crops grown and cropping pattern in Diamer is influenced by the elevation which ranges from about 1,250 m to above 3,000 m. Sowing and harvesting of crops varies from zone to zone. Below 2,500 m, double cropping system is practiced whereas above 2,500 m single cropping pattern is practiced. The major cereal crops of the districts are maize and wheat. The vegetables grown include potato, capsicum, tomato, peas, cabbage, cucumber, carrot, radish, okra, and beans. The major fruits of the district are apricot, apple, grapes, pear, peaches, pomegranate, mulberry, walnut, and almond. Fodder is also produced in sufficient quantity. It is important to mention that farmers grow multiple crops for subsistence in the same season. A typical cropping pattern followed in Diamer is given in **Table 2.**

Table 2. Current cropping pattern

Altitude (m) and major locations (examples)	Cropping Pattern
Altitude: 1250 to below 2500 **Cropping season:** Feb – Oct Double cropping **Major locations:** Luruk, Chilas central, Thor, Hudur, Gini, Gas, Bonner Das, Gonner Farm, Jal, Dashal, Single, Goharabad, Thalichi	• Winter: Wheat • Summer: Maize or potato with vegetable (capsicum, peas, tomato, radish, Chinese cabbage, mellow plant, turnip, and others) • Vegetables are grown side by side the crops • Fodder as irrigated perineal crop • Fruits are grown
Altitude: 2500 to below 2800 **Cropping season:** March–Oct; Single cropping **Major locations:** Thak, Goharabad, Juglot, Ghumari, Sateel, Makhili, Lower Babusar, Batogah	• Winter: Wheat • Summer: Potato or Maize or barley with vegetable (capsicum, peas, radish, cauliflowers, tomato, turnip, and others) • Vegetables are grown side by side the crops • Fodder as irrigated perineal crop • Fruits are grown
Altitude: above 2800 **Cropping season:** Late March–September; Single cropping **Major locations:** Matikeh, Aat, Goharabad upper, Khanbary, upper Babusar, Fairy Meadows, Malpat	• Maize OR • Peas OR • Wheat OR • Potato • Vegetables parallel to crops or intercropped (turnip and others) • Fodder as irrigated perineal crop • Few fruits

Source: Primary data from district consultation workshops and interviews June 2022

[1] GB at a glance 2020. Government of Gilgit Baltistan
[2] Ibid
[3] Agriculture Statistics Report 2014. Gilgit Baltistan
[4] https://www.citypopulation.de/en/pakistan/cities/gilgitbaltistan
[5] GB at a Glance 2020. Government of Gilgit Baltistan
[6] Agriculture Census 2020, department of Agriculture Gilgit Baltistan

4. Soil characteristics

Soil characteristics of Diamer are dominated by parent material. The most dominant soil type is Eutric Cambisol. The Eutric Cambisols in temperate zones are among the most productive soils on earth. Some of these soils on steep slopes are covered by forests. Lithomorphic soils form the second dominant type of soil in Diamer. Most of these soils are at the peripheries of the district bordering Astore and Gilgit. Lithomorphic soils are less than 30 centimeter (cm) deep and consist only of a topsoil over parent material which may be solid rock or loose sediment. Such soils are at a very early stage of formation with slowly weathering material, and due to coarse texture lithosols are highly prone to erosion and degradation. Gleysols represent minority type of soil shared with Astore. These soils are found on gentler slopes, and not essentially well drained.

The organic matter seems to be adequate, especially in Cambisol areas, whereas NPK seem to be consistently low in quantity, especially in Lithosol areas, and need to be managed. The most prominent soil structure in Diamer is silty clay loam followed by silty loam. The pH is slightly acidic in areas adjoining Astore (Bunji, Doyan) and more neutral to slightly alkaline in the rest of the district. **Table 3** summarises major soil characteristics.

Table 3. Summary of soil characteristics

Parent material	Organic Matter (%)	Fertility			Soil texture		pH
		NO3-N (mg kg^{-1})	P (mg kg^{-1})	K (mg kg^{-1})			
Cambisols 50% Lithosols 40% Gleysols 10%	Adequate	Low	Low	Adequate	Silty clay loam 60%	Silt loam 40%	Neutral to slightly alkaline above 2135 m Slightly Acidic-neutral below 2135 m

5. Climate trends

The biggest increase in daytime temperature was noted in spring season whereas temperature trend is on the rise for all the months from January to October during the period 1991-2020. There is a slightly decreasing trend for the months of November and December. The annual average daytime temperature for Diamer has increased from 9.7°C to 10.2°C, i.e., an average increase of 0.5°C since 1960. However, increase for the period 1960 to 1990 is only 0.3°C whereas increase for 1991 to 2020 is 0.7°C. It is thus concluded that a greater warming trend is noted during the last thirty years.

Against the base year of 1960 the trend in night temperatures is of continuous increase in all months with minimum increase of 0.4°C in the month of November and maximum increase of 2.2°C in the month of April followed by October with 2.1°C. With respect to seasonal trends, the maximum increase was noted in spring months followed by autumn and then summers. This suggests that nights in Diamer are becoming warmer throughout the year but more significantly in spring and autumn. Also, it shows that nights are warming more significantly than the days.

The following sub sections provide details on day and night temperatures (**Tables 4 and 5**), and precipitation (**Table 6**). The analysis in these sections is based on average conditions. There may be year to year variations (e.g., cold wave during spring, or wet than average or drier than average). This climate variability is not accounted for in ascertaining climate change trend.

5.1 Analysis of maximum temperature

- Mean monthly day time temperature during the winter months is overall increasing except in December. The temperature in December had increased between 1960 and 1990. However, it has returned to the level of 1960 during the next thirty years.
- Day temperatures in spring season are increasing with the largest increase noted in the months of March and April.
- Summer days are showing a warming trend, but very little when compared to the base year of 1960.
- Autumn day temperatures have increased for October but decreased in November.

Table 4. Trend analysis of mean monthly maximum temperature (°C)

	1960-2020			1960-1990			1991-2020		
Months	Change from - to	Change in temperature	Trend	Change from - to	Change in temperature	Trend	Change from - to	Change in temperature	Trend
Dec	0.2 to 0.7	0.5	↑	0.2 to 0.8	0.6	↑	1 to 0.2	-0.8	↓
Jan	-2.6 to -2.4	0.2	↑	-2.8 to -2	0.8	↑	-2.9 to -2.2	0.7	↑
Feb	-1.7 to -0.6	1.1	↑	-1.5 to -1.6	-0.1	↓	-1 to -0.6	0.4	↑
Mar	3.2 to 4.6	1.4	↑	4.2 to 3	-1.2	↓	3.4 to 5.2	1.8	↑
Apr	8.9 to 10.5	1.6	↑	8.8 to 10.1	1.3	↑	9.2 to 10.8	1.6	↑
May	13 to 14.3	1.3	↑	12.9 to 14.1	1.2	↑	13.4 to 14.6	1.2	↑
Jun	18.6 to 18.1	-0.5	↓	18.8 to 18.3	0.5	↓	17.8 to 18.5	0.7	↑
Jul	20.5 to 20.5	0	↔	20.6 to 20.6	0	↔	20.1 to 20.8	0.7	↑
Aug	20.2 to 19.9	-0.3	↓	20.2 to 20	-0.2	↓	19.8 to 20	0.2	↑
Sep	17.5 to 17.7	0.2	↑	17.3 to 17.9	0.6	↑	17.2 to 17.8	0.6	↑
Oct	12.2 to 12.8	0.6	↑	12.4 to 12.2	-0.2	↓	12.1 to 13.1	1	↑
Nov	5.8 to 6.8	1	↑	5.4 to 6.9	1.5	↑	7 to 6.2	-0.8	↓

5.2 Analysis of minimum temperature

- Mean monthly night temperatures in winters have increased with respect to 1960 except in December which shows a decreasing trend.
- Just like the day temperatures, night temperatures in spring are also increasing. Among all the seasons, the temperature increase is the highest during the spring season. Spring is becoming warmer as both the day and night temperatures are increasing which may allow early sowing of crops. On the other hand, a rise in temperature will not allow late snow to consolidate and will result in flash floods during the spring season.
- Night temperatures in the summer months showed a decreasing trend from 1960 to 1990 but this trend reversed in the period 1991-2020 and started increasing. The highest increase is observed in the month of September.
- The warming trend is also observed in autumn with the highest increase in October in the period 1991-2020.

Table 5. Trend analysis of mean monthly minimum temperature (°C)

	1960-2020			1960-1990			1991-2020		
Month	Change from - to	Change in temperature	Trend	Change from - to	Change in temperature	Trend	Change from – to	Change in temperature	Trend
Dec	-8.8 to -7.4	1.4	↑	-9.5 to -7.4	2.1	↑	-7.5 to -8.3	-0.8	↓
Jan	-11.4 to -10.7	0.7	↑	-11.8 to -10.2	1.6	↑	-10.9 to -10.4	0.5	↑
Feb	-10.4 to -9	1.4	↑	-10 to -10.3	-0.3	↓	-9.6 to -9	0.6	↑
Mar	-6 to -4.1	1.9	↑	-5.5 to -5.5	0	↔	-5.5 to -3.6	1.9	↑
Apr	-1.2 to 0.6	1.8	↑	-1 to -0.3	0.7	↑	-1 to 1.2	2.2	↑
May	1.8 to 2.8	1	↑	1.7 to 2.9	1.2	↑	2.5 to 4	1.5	↑
Jun	6.3 to 6.7	0.4	↑	6.6 to 6.3	-0.3	↓	6.2 to 7	0.8	↑
Jul	8.8 to 9.5	0.7	↑	9.1 to 8.9	-0.2	↓	8.7 to 10	1.3	↑
Aug	8.4 to 9.2	0.8	↑	8.7 to 8.7	0	↔	8.3 to 9.7	1.4	↑
Sep	4.3 to 5.4	1.1	↑	4.7 to 4.6	-0.1	↓	4.3 to 5.9	1.6	↑
Oct	-0.7 to 0.9	1.6	↑	-0.3 to -0.3	0	↔	-0.6 to 1.5	2.1	↑
Nov	-5.2 to -4.3	0.9	↑	-5.4 to -4.4	1	↑	-4.7 to -4.3	0.4	↑

5.3 Analysis of precipitation

Annual precipitation has remained almost the same since 1960 with shifting of precipitation from one season to another. Key findings are:

- Winters precipitation has slightly increased in the form of snow.
- The most significant decline is noted in the spring rainfalls.
- In summers, the rainfall increased slightly between 1960 to 1990. The trend since 1991 is on a decline.
- Not much change has been noted in the autumn precipitation.

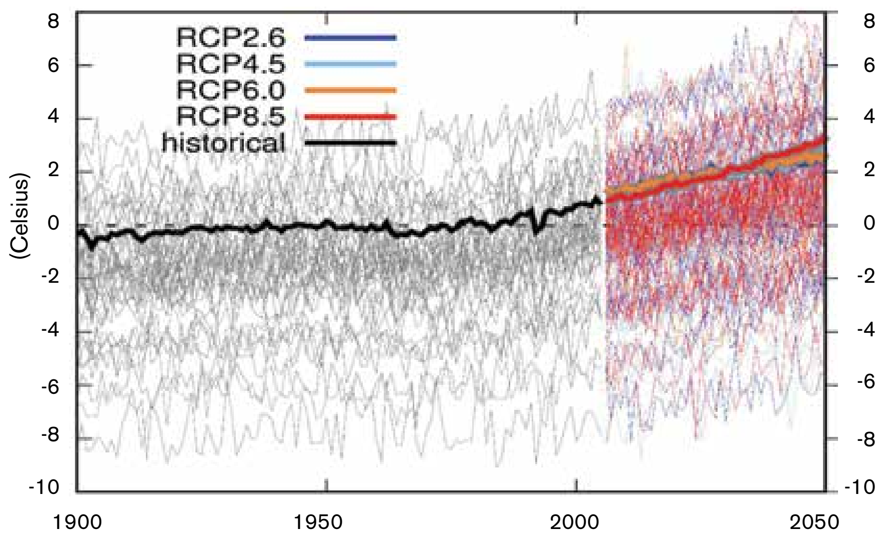
Table 6. Trend analysis of annual and seasonal precipitation (mm)

	1960-2020			1960-1990			1991-2020		
Season	Change from - to	Change in precipitation	Trend	Change from - to	Change in precipitation	Trend	Change from - to	Change in precipitation	Trend
Annual	532 to 564	32	↑	504 to 580	76	↑	570 to 538	-32	↓
Winter	124 to 145	21	↑	118 to 142	24	↑	136 to142	6	↑
Spring	225 to 174	-51	↓	205 to 186	-19	↓	190 to 174	-16	↓
Summer	164 to 204	40	↑	142 to 204	62	↑	206 to 180	-26	↓
Autumn	42 to 42	0	↔	38 to 50	12	↑	36 to 44	8	↑

5.4 Climate scenarios

Figure 1 presents near surface temperature projections till 2050 based on different emissions scenarios and how these emissions will affect the temperature in Diamer. Taking the historical trend from 1900, the time series projects that under different scenarios the average temperature of Diamer will be between 2.5°C and 3.2°C which at the turn of the century was below 0°C. This is quite high and suggests an average rise in temperature by 2.8°C by end of 2050. **Figure-1** provides projection for temperature in the district till 2050.

Figure 1. Temperature projection till 2050



Source: IPCC Assessment Report 5 – 2014

To adapt to these changes, farmers will have to rely more on irrigation than on rains. The early snowmelt may be advantageous for agriculture, although risk of flash floods in spring may increase. In spring and summer, farmers will be dependent on irrigation because rains are declining in these seasons. During late summer and autumn, irrigation water will be short due to early snowmelt. Increased temperature does not allow snow to stay long and contribute to glacial reserves, which is important for sustainable water flows. Warming of this region therefore is not in favour of longer-term water security of the region.

6. Agro-ecological zones

Diamer is one of four districts with Astore, Gilgit and Ghizer where all Agro-ecological zones (AEZs) prevail. This can be a management challenge as well as an opportunity for agricultural diversity. **Figure 2** presents an AEZs map of Diamer which is supported by **Table 7** with major locations falling in various zones. **Figure 3** presents percentage of each zone prevalent in the district.

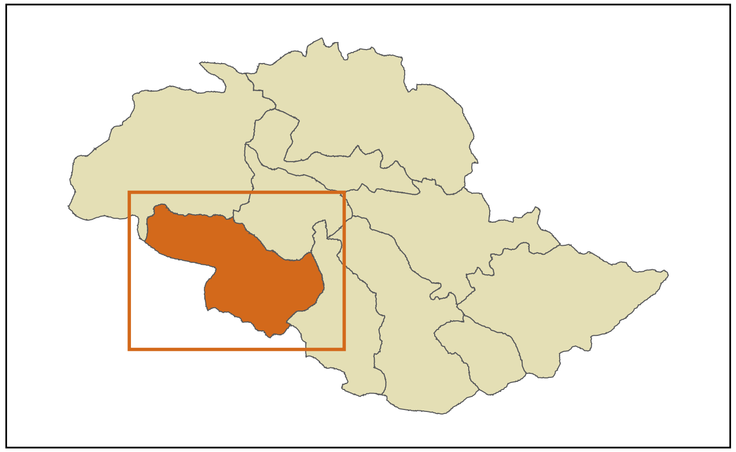


Figure 2. Agroecological zones of Diamer District

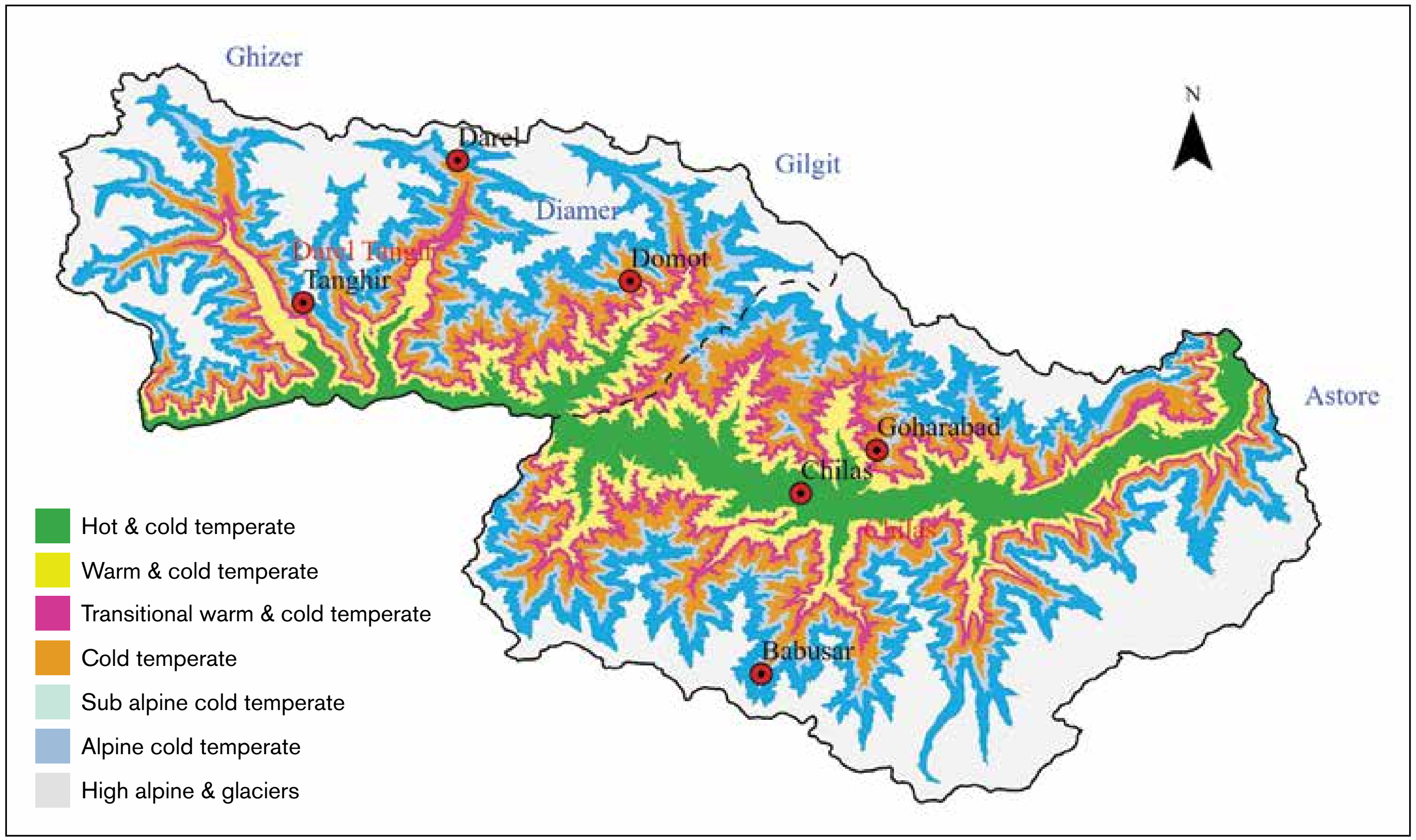
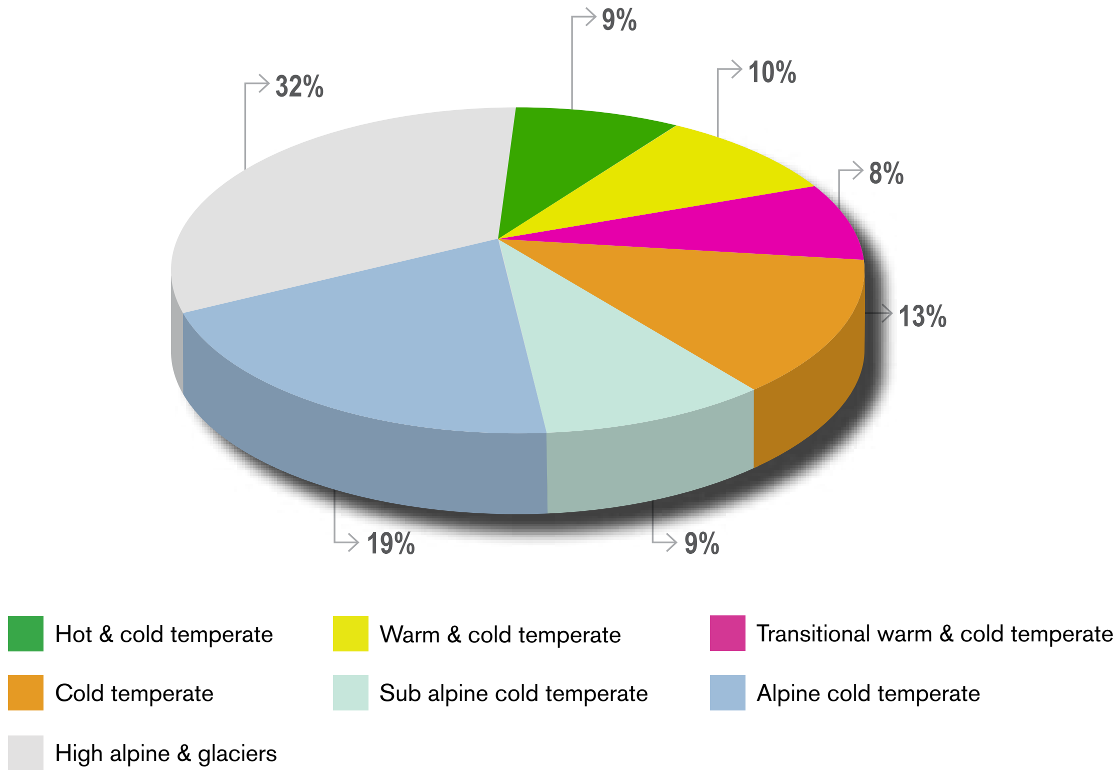


Table 7. Major locations falling in various AEZs

Agro-ecological zones	Major locations
Hot & Cold Temperate Alleviation: 4,000-5,500 feet (1,220-1,700 m) Avg. Temp.: 4.5°C Avg. Prec.: 427 mm	Major area of the district is in this zone and runs all across the district. Major locations of zone's are as follows: Tangir: Luruk. Darel: Phoguch, Sut Das, Gayal, Hedokail Dudishal, Nararay Khanbery, Bailow Khanbary. Chilas: Chilas central, Thor Das, Hudur Das, Thalpan Khiner, Lower Gini, Gas Bala and Payeen, Bonner Das, Lower Gonner Farm, Kino Das, Daran Goharabad, Thalichi
Warm & Cold Temperate Alleviation: 5,500-7,000 feet (1,720-2,150 m) Avg. Temp.: 4.4°C Avg. Prec.: 389 mm	Locations are as follows: Tangir: Rim Sheikh, Juglot, Diamer, Gali Payeen and Bala. Darel: Samaigal Payeen and Bala, Gumari, Shahi Mahal, Jut Dudishal, Sair, Dasoi Khanbery. Chilas: Hudur: Dang pehari, Topar Hudur. Thor: Sari, Kot, Waray, Thaak, Hachay, Sairdas. Khinar: Butogah: Khay, Mashi. Thak: Dasar, Thak Kot, Thay Niat; Bunar Nala, Thamarus. Upper Gonner Farm: Gais, Duga. Goharabad: Goharabad mid, Dirkil, Phuski, Datche.
Transitional Warm & Cold Temperate Alleviation: 7,000-8,000 feet (2,150-2,450 m) Avg. Temp.: 3.9°C Avg. Prec.: 419 mm	Tehsil Darel has a larger prevalence of Transitional temperate zone. The locations are as follows: Tangir: Phaphat, Korangai. Darel: Manikal Payeen, Manikal Bala, Biari, Geot, Khanbery: Gishar, Dabot, Khurin. Chilas: Hudur – Molodas, Thor – Doga, Dyong. Khiner – Totam. Butogah: Chakar, Beraydat. Thak: Dyong, Loshi. Gushar, proper Niat. Goharabad upper: Khartalot, Gittelay
Cold Temperate Alleviation: 8,000-9,500 feet (2,450-2,900 m) Avg. Temp.: 3.2°C Avg. Prec.: 441 mm	This zone prevails in all the tehsils along lower zones. Tangir: Sateel Tangir, Upper Korangai. Darel: Gabar, Yashot, Jaduri, Khanbery Manin, Thilkush, Banogah. Chilas: Hudur: Suri chap. Thor: Makhili. Babusar: Lower Babusar, Niat Khatay. Batogah: Sumall, Martel. Goharabad: Damreli, Tatto Muthat.
Sub Alpine Cold Temperate Alleviation: 9,500-10,500 feet (2,900-3,200 m) Avg. Temp.: -3.5°C Avg. Prec.: 339 mm	A larger prevalence of this zone is in Darel. The locations are noted as follows. Darel: Dubulus (Gayal Darel), Matikeh, Aat. Khanbery: Datay. Niat: Kaami, Babusar. Chilas: Goharabad: Gais Payeen, kosach
Alpine Cold Temperate Alleviation: 10,500-12,500 feet (3,200-3,800 m) Avg. Temp.: -4.0°C Avg. Prec.: 259 mm	A larger prevalence of this zone is in Darel. The locations are noted as follows. Darel: Matikeh summer settlement, Diagarh Gayal, Khanbery: Naroon Namal, Narnaygah. Chilas: Koota Babusar, Fairy Meadows, Malpat
High Alpine and Glaciers Alleviation: 12,500 feet + (3,800 m +) Avg. Temp.: -7.1°C Avg. Prec.: 227 mm	3800 meters above sea level and higher. This is an area which is only used as high-altitude pastures and not for crops.

Figure 3. Percentage area under various AEZs

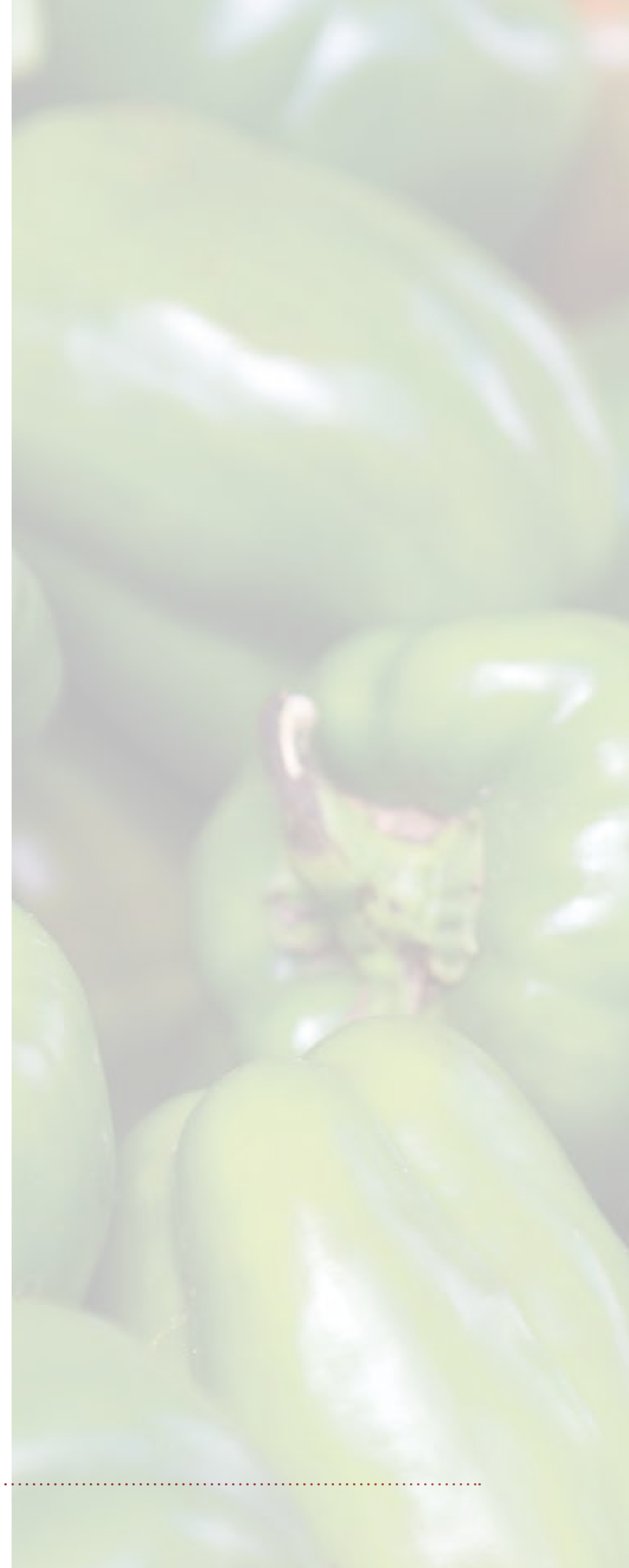


7. Agricultural potential

The following potential (**Table 8**) has been identified after consultations with Agriculture Department and the farming community as well as assessing the market potential pertaining to crops grown in various AEZs of the district. In addition to introducing an appropriate cropping pattern, soil fertility management and erosion control are imperative in Diamer due to soil characteristics described earlier.

Table 8. Potential of crops in various AEZs

Type	Potential crops	Remarks
		Potential in Hot & Cold Temperate zone
Cereals	Maize, wheat (winter sowing)	Winter wheat followed by Maize in summer is the first priority in this zone. Winter wheat is a priority cereal to be sown for subsistence and to contribute to self-sufficiency of GB in wheat grain since it will not compete with other crops. Farmers reported that seed for winter wheat is a challenge and needs to be arranged on timely basis. Also use of certified maize seed is important.
Vegetables	Capsicum, okra, tomato	Capsicum, okra, and tomato (two crops, February and August) are highly recommended in this zone which is already in demand. Tomato has a seasonal advantage with early variety and product arriving when tomato is in short supply in the rest of GB and also in other parts of the country. In addition, cucumber, Chinese cabbage, radish, mallow plant (swanchal) and peas grow quite well in this zone. Cucumber, tomato, bell pepper/capsicum, bitter gourd and other suitable vegetables are recommended to be cultivated in vertical farming tunnels for greater benefit in limited space.
Fruit	Pomegranate, grapes, persimmon, citrus, plum	Top priority fruits in this zone are pomegranate and persimmon from marketing point of view. Persimmon has a high demand in down country. Grapes and pomegranate need varietal development.
Fodder	Trifolium, Alfalfa	Fodder is a cash crop in Diamer. Trifolium is cultivated in the field and alfalfa in the field on marginal lands.
		Potential in Warm & Cold Temperate zone
Cereals	Maize	Maize is the first priority in this zone with winter wheat. Wheat is important for subsistence and contributing to grain self-sufficiency in GB and for straw as fodder.
Vegetables	Capsicum, peas, tomato	Capsicum, followed by peas are in high demand in the market. Cucumber and tomato are recommended to be raised in vertical farming. Other significant vegetables include mallow plant, onion and potentially okra, red beans and maash (pulse). Red beans may be intercropped with maize and acquire good yields.
Fruit	Walnut, apple, grapes, pomegranate	Walnut is a high potential crop for developing household industry for kernel and oil. This zone shows a greater affinity for apples and pomegranates due to no attack by a traditional pest called coddling moth and fruit fly. Grapes suffer powdery mildew.
Fodder	Trifolium / Alfalfa	Cultivated separately as well as intercropped in standing maize.
		Potential in Transitional Warm & Cold Temperate zone
Cereals	Maize, wheat (winter sowing only)	Maize is a primary cereal crop in this zone. Wheat currently cultivated in spring must shift to winter. The shift will make limited agricultural lands available for other high value crops in summer.



Vegetables	Potato, peas, capsicum	Farmers may decide to either grow winter wheat or leave the land fallow during winter for cultivating potato in the spring. Potato harvesting may follow cultivation of short duration crops e.g., fodder or peas. Capsicum is also successful in this zone due to warming temperatures. Tomato and cucumber are strongly suggested to be cultivated in vertical farming tunnels for greater benefit. Intercropping of red beans intercropped with maize is a regular practice and appropriate in this zone.
Fruit	Walnut, apple, apricot	Quality of walnut in this zone is very good. Cultivating apple is an increasing trend. Apricot also performs very well in this zone.
Fodder	Trifolium / Alfalfa	Cultivated separately as well as intercropped in standing maize.
Potential in Cold Temperate zone		
Cereals	Maize	Maize is the main cereal crop preferred in this zone and is suitable as per zone's characteristics.
Vegetables	Peas, potato, red beans	Potato and peas are highly viable cash crops in this zone. Red beans are intercropped with maize. Pumpkin, turnip, radish, and cabbage are also highly recommended. Currently these vegetables are cultivated on a limited scale due to remoteness and limited market connectivity. Radish in the field and cucumber and green gourd in vertical formation may be cultivated for self-consumption.
Fruit	Walnut, apple, apricot	Quality of walnut in this zone is very good. Cultivating apple is an increasing trend. Apricot also performs very well in this zone.
Fodder	Irrigated natural pastures and crop by-products	No specific cultivation.
Potential in Sub Alpine Cold Temperate zone		
Cereals	Maize	Short duration maize is recommended for this zone.
Vegetables	Potato and peas	Potato is the only and most viable cash crop in this zone. In addition, peas may be an alternative crop for cash with potato. Pumpkin performs well in this zone as well.
Fruit	None	Although fruits may be cultivated for self-consumption, their performance may not reach economic scale.
Fodder	Natural pastures and crop by-products	No specific cultivation.
Potential in Alpine Cold Temperate zone		
Cereals	None	Too cold for cereal production.
Vegetables	Mallow plant, potato	Mallow plant, potato may be cultivated for self-consumption. Radish and turnip may also be cultivated for subsistence.
Fruit	None	Not suited for conventional fruit crops.
Fodder	Natural pastures and crop by-products	No specific cultivation.


Agro-Ecological Zones
District Ghanche
HUNZA
GHIZER
NAGAR
GILGIT
SHIGAR
GHANCHE
DIAMER
ASTORE
KHARMANG
SKARDU

Ghanche

Latitude 35.1625° N and Longitude 76.3360° E

1. Introduction

District Ghanche is situated in the Baltistan region. The district is spread over an area of 8,531 sq.km (853,100 ha) which is 12% of the total area of Gilgit-Baltistan (GB)[1]. District Ghanche is at a strategic location. The district is bordered by China in north-east, Indian occupied Ladakh in the south, Skardu district in west and Shigar district in north-west. In Balti language Ghanche means 'the land of glaciers. There are many glaciers in Ghanche including the largest and famous Siachen glacier. The district headquarter is Khaplu town. The district is located at an elevation ranging from 2499 meters (m) to 3109 m. Ghanche is home to some of the highest peaks such as Masherbrum, Sia Kangri, Saltoro Kangri, K7, K6, Laila Peak, Naiza Peak and Amin Braq. The Hushe valley which is a hub of adventure tourism in Baltistan is also located in district Ghanche. Administratively, Ghanche district is divided into three tehsils, namely Khaplu, Kharko and Mashabrum. The population of the district in 2017 was 160,000 with 23,529 households at an average household size of 6.8[2] in 69 villages[3]. With a growth rate of 3.17[4], the estimated population of the district in 2022 is 187,020. The overall literacy rate in district Ghanche is 43% - male 56% and female 34%[5].

2. Land use statistics

According to Agriculture Department GB, the total agricultural land of the district is 7,181 hectares (ha) out of which 3,779 ha is cultivated while 3,402 ha is cultivable waste[6]. The land use statistics of the district are given in **Table 1.**

Table 1. Land use statistics

S.No.	Type of Land	Area (Ha)	Percentage
1.	Agricultural Land	7,181	0.8%
2.	Forest Land	4,878	0.6%
3.	Range Land & Pastures	124,264	14.6%
4.	Rivers/Lakes	28,515	3.3%
5.	Built up Area	15,185	1.8%
6.	Snow/Glaciers	329,079	38.6%
7.	Rocks	343,998	40.3%
	Total	**853,100**	**100%**

Source: Calculated using GIS tools based on district shape files provided by GB Agriculture department 2022

3. Current features of agriculture

The crops grown and cropping pattern in Ghanche is influenced by the elevation which ranges from about 2500 m to over 3000 m. The major cereal crops of the district are wheat, barley, maize, millet, and buckwheat. Beans are mostly intercropped. Vegetables grown are potato, peas, tomato, cucumber, Chinese cabbage, radish, carrot, and beans. Major fruits of the district include apricot, apple, mulberry, walnut, and almond. Cherry, pear, peaches, and grapes are also grown. Most of the fruit trees are scattered and not in orchard form. Fodder is also produced in sufficient quantity. It is important to mention that farmers grow mix crops for subsistence in the same season. The typical cropping pattern followed in the district is given in **Table 2.**

Table 2. Current cropping pattern

Altitude (m) and major locations (examples)	Cropping Pattern
Altitude: 2469 to below 2682 **Cropping season:** 3rd week Mar – Sep Single cropping **Major location:** Keris, Ghwari, Kuro, Yugo, Khaplu, Saling, Balghar, Daghoni	• Wheat – fallow – OR • Wheat followed by fodder – OR • Barley followed by millet – OR • Barley followed by vegetables – OR • Potato – fallow • Vegetable on small areas parallel to crops • Fodder as irrigated perineal crop • Fruits are extensively grown
Altitude: 2682 to below 2896 **Cropping season:** April – Aug Single cropping **Major location:** Khayor Khaplu, Kanday, Chorbat, Thagusm Machulu	• Wheat – fallow – OR • Barley followed by millet – OR • Barley followed by buckwheat – OR • Potato – fallow • Vegetable on small areas parallel to crops • Fodder as irrigated perineal crop • Fruits in large quantities
Altitude: 2896 and above **Cropping season:** Middle April – Aug Single cropping **Major locations:** Saltoro, Mashabrum, Hushe	• Wheat – fallow – OR • Barley – fallow – OR • Buckwheat fallow – OR • Potato – fallow • Vegetable on small areas parallel to crops • Fodder as irrigated perineal crops • Fruits in small quantities

Source: Primary data from district consultation workshops and interviews June 2022

[1] GB at a glance 2020. Government of Gilgit Baltistan
[2] Ibid
[3] Agriculture Statistics Report 2014. Gilgit Baltistan
[4] https://www.citypopulation.de/en/pakistan/cities/gilgitbaltistan
[5] GB at a Glance 2020. Government of Gilgit Baltistan
[6] Agriculture Census 2020, department of Agriculture Gilgit Baltistan

4. Soil characteristics

Ghanche is the only district in GB with all four soil types. Lithosols and Gleysols are the most dominant soil types. Lithomorphic soils are thin (less than 30cm deep) with slowly weathering coarse textured parent material, highly prone to land degradation and erosion. Sustainable crop production is a challenge on these soils since these soils need a lot of care and conservation measures. These soils prevail along borders with lower Shigar and a bit with Kharmang near international border. More attention is required for its conservation; if this shallow soil is lost, it will be a long weathering process before new soil is formed. Gleysoils represent the second extensive soil cover in Ghanche. These soils, however, are found on high altitudes at the base of Mashabrum and beyond with ice and glacial reserves. There is a small U-shaped strip of Orthic Acrisols which are usually problematic for agriculture. Orthic Acrisols are deep, well drained, dark brown loamy soils with roots mainly confined to the topsoil. Within this u-shaped strip, there is a strip of Eutric Cambisol which is among the most productive soils on earth. This constellation of Orthic Acrisols and Cambisols exists around Chorbut area and below.

Sandy loam is a prominent soil texture found in Ghanche. Organic matter is relatively marginal, except in areas adjoining Skardu, and the pH is slightly acidic to neutral. **Table 3** summarises soil characteristics of Ghanche.

Table 3. Summary of soil characteristics

Parent material	Organic Matter (%)	Fertility			Soil texture		pH
		NO3-N (mg kg^{-1})	P (mg kg^{-1})	K (mg kg^{-1})			
Lithosols 45% Gleysols 35% Orthic Acrisols 15% Cambisols 5%	Marginal	Low	Low	Low	Sandy loam 90%	Silt loam 10%	Slightly Acid-ic-neutral in lower Ghanche Neutral to slightly alkaline in higher areas

5. Climate trends

Pronounced climatic changes, particularly in the temperatures, have occurred in Ghanche since 1960. The most noticeable changes were observed in spring season. The average day time temperature has increased to 4.1°C from 3.4°C since 1991. Nights in Ghanche are becoming warmer in all the months at a faster rate than the days which should be worrisome, particularly, because major glaciers are located in this district and increasing temperatures will accelerate melting rate of glaciers.

Precipitation has mostly increased except in case of spring season.

Following sub sections provide details on day and night temperatures (**Tables 4 and 5**), and precipitation (**Table 6**). The analysis in these sections is based on average conditions. There may be year to year variations (e.g., cold wave during spring, or wetter than average or drier than average). This climate variability is not accounted for in ascertaining climate change trend.

5.1 Analysis of maximum temperature

- Mean monthly day temperature during the winter months is overall increasing. A major change is noted in the months of January and February. In case of December though the temperature has increased with respect to 1960 but is showing a declining trend since 1991.
- Day temperatures in spring season are also increasing. March and April show a large change of around 2°C since 1991.
- Day temperatures in summer months have declined as compared to 1960 but are showing an increasing trend since 1991 for all months except August which shows no change.
- Day time temperatures in autumn are increasing for October but decreasing in November.

Table 4. Trend analysis of mean monthly maximum temperature (°C)

Months	1960-2020			1960-1990			1991-2020		
	Change from - to	Change in temperature	Trend	Change from - to	Change in temperature	Trend	Change from - to	Change in temperature	Trend
Dec	-6.6 to -6.1	0.5	↑	-6.5 to -6.5	0	↔	-6 to -6.3	-0.3	↓
Jan	-9.6 to -9.6	0	↔	-9.6 to -9.1	0.5	↑	-9.9 to -9.2	0.7	↑
Feb	-8.5 to -7.2	1.3	↑	-8.2 to -8.3	-0.1	↓	-7.6 to -7.2	0.4	↑
Mar	-2.8 to -1.4	1.4	↑	-1.8 to -3.4	-1.6	↓	-2.7 to -0.7	2	↑
Apr	2.7 to 4.2	1.5	↑	3 to 3.4	0.4	↑	2.8 to 4.7	1.9	↑
May	6.3 to 7.2	0.9	↑	6.4 to 6.7	0.3	↑	6.6 to 7.4	0.8	↑
Jun	11.7 to 10.7	-1	↓	12.1 to 10.8	-1.3	↓	10.9 to 11.1	0.2	↑
Jul	16 to 15.8	-0.2	↓	16.2 to 15.8	-0.4	↓	15.7 to 16.1	0.4	↑
Aug	15.6 to 15.1	-0.5	↓	15.6 to 15.4	-0.2	↓	15.2 to 15.2		↔
Sep	12.2 to 12.2	0	↔	12.2 to 12.2	0	↔	11.9 to 12.4	0.5	↑
Oct	5.5 to 5.9	0.3	↑	6 to 5.2	-0.8	↓	5.3 to 6.3	1	↑
Nov	-1.4 to -0.4	1	↑	-1.5 to -1	0.5	↑	-0.6 to -0.7	-0.1	↓

5.2 Analysis of minimum temperature

- Mean monthly night temperatures during the winter months are overall increasing since 1960. This increase is between 1.6 and 2°C. More of this increase took place between 1960-1990. During the last thirty years, temperature in January and February continues to increase except December which remains unchanged with respect to 1990.
- The increase in night temperatures is more as compared to day temperatures in the spring months as a result making springs warmer. This may allow farmers early sowing of crops but

may not allow the snow to consolidate and can cause flash floods during the spring season.

- Summer nights are also becoming warmer as night temperatures are increasing more than the daytime temperatures similar to the spring season with a maximum change observed in the month of September since 1960.
- Due to increased temperature in October and November, the autumn is becoming milder.

Table 5. Trend analysis of mean monthly minimum temperature (°C)

	1960-2020			1960-1990			1991-2020		
Months	Change from - to	Change in temperature	Trend	Change from - to	Change in temperature	Trend	Change from - to	Change in temperature	trend
Dec	-18.6 to -16.6	2	↑	-19 to -17.3	1.7	↑	-17 to -17	0	↔
Jan	-21.2 to -19.6	1.6	↑	-21.5 to -19.9	1.6	↑	-20.3 to -19.8	0.5	↑
Feb	-19.8 to -18.1	1.7	↑	-19.5 to -19.5	0	↔	-18.7 to -18.1	0.6	↑
Mar	-14.5 to -12.4	2.1	↑	-14 to -14	0	↔	-13.8 to -11.9	1.9	↑
Apr	-9.8 to -7.4	2.4	↑	-9.4 to -9	0.4	↑	-9.4 to -6.7	2.7	↑
May	-7.5 to -4.9	2.6	↑	-7.3 to -6.4	0.9	↑	-6.4 to -4.7	1.7	↑
Jun	-1.8 to -0.5	1.3	↑	-1.3 to -1.7	-0.4	↓	-1.5 to -0.1	1.4	↑
Jul	1.8 to 3.2	1.4	↑	2.4 to 1.9	0.5	↑	2.1 to 3.6	1.5	↑
Aug	1.6 to 3	1.4	↑	2.1 to 1.9	0.2	↑	1.7 to 3.6	1.9	↑
Sep	-2.9 to -1.2	1.7	↑	-2.2 to -2.7	-0.5	↓	-2.4 to -0.7	1.7	↑
Oct	-9.2 to -7	2.2	↑	-8.4 to -8.8	-0.4	↓	-8.9 to -6.1	2.8	↑
Nov	-14.9 to -12.9	2	↑	-14.7 to -14.1	0.6	↑	-14.2 to -12.7	1.5	↑

5.3 Analysis of precipitation

Annual precipitation has increased since 1960 but this increase was in the period 1960-1990. It started declining since 1991. The key findings from the data are:

- There is slightly more precipitation during autumn and winters.
- More snow is reported than rains.
- Spring rains are on the decline.

Table 6. Trend analysis of annual and seasonal precipitation (mm)

	1960-2020			1960-1990			1991-2020		
Trend	Change from - to	Change in precipitation	Trend	Change from - to	Change in precipitation	Trend	Change from - to	Change in precipitation	Trend
Annual	218 to 238	20	↑	215 to 247	32	↑	238 to 225	-13	↓
Winter	65 to 78	13	↑	58 to 80	22	↑	72 to 75	3	↑
Spring	102 to 98	-4	↓	101 to 99	-2	↓	113 to 89	-24	↓
Summers	28 to 41	13	↑	25 to 38	13	↑	38 to 38	0	↔
Autumn	24 to 21	-3	↓	20 to 30	10	↑	16 to 24	8	↑

5.4 Climate scenarios

Figure 1 is based on near surface temperature and presents projections till 2050. It is based on different GHG emissions reduction scenarios and how these emissions will affect the temperature in Ghanche. Taking the historical trend from 1900, the time series projects that under different GHG emissions reduction scenarios the average temperature of Ghanche will be between -2°C and -1°C, which at the turn of the century was around -5°C. This clearly shows that warming of Ghanche continues to take place under different emission scenarios.

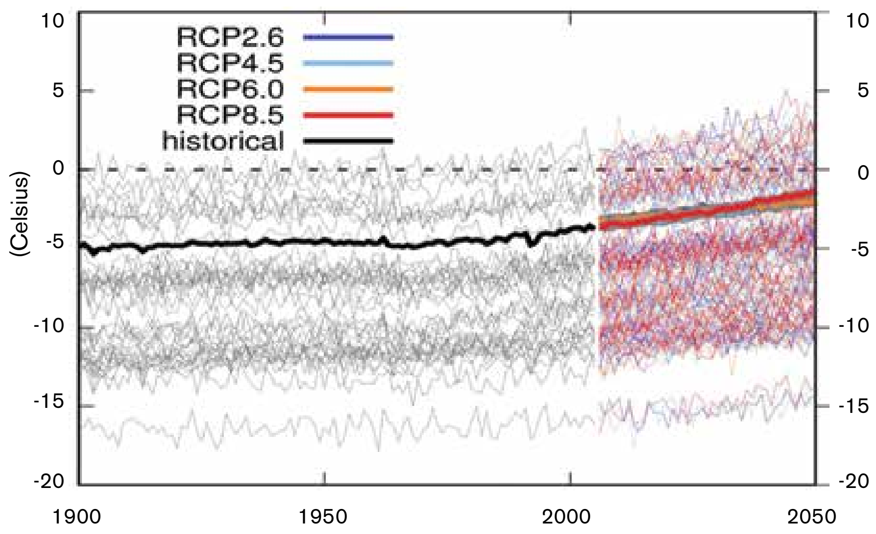


Figure 1. Temperature projection till 2050

Source: IPCC Assessment Report 5 – 2014

6. Agro-ecological zones

Ghanche district comprises five Agro-ecological zones (AEZs). **Figure 2** shows AEZs in the district which is supported by **Table 7** which provides some of the major locations falling in different zones. **Figure 3** provides percentage area of the district falling under various AEZs. Ghanche has a very little transitional warm & cold temperate zone adjoining Skardu. Most of Ghanche falls under the Alpine Cold Temperate single cropping zone.

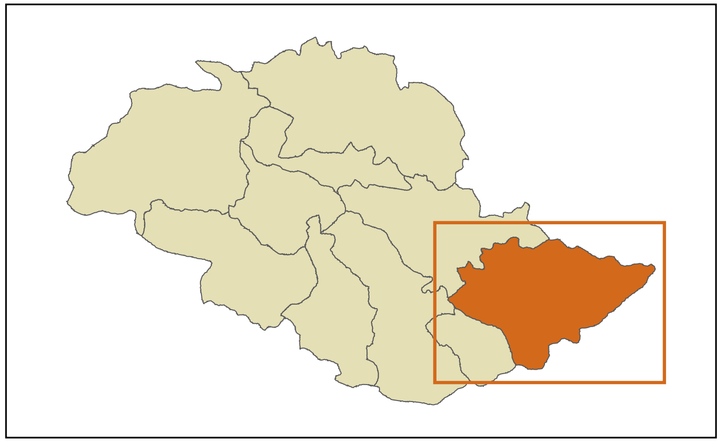


Figure 2. Agroecological zones of Ghanche District

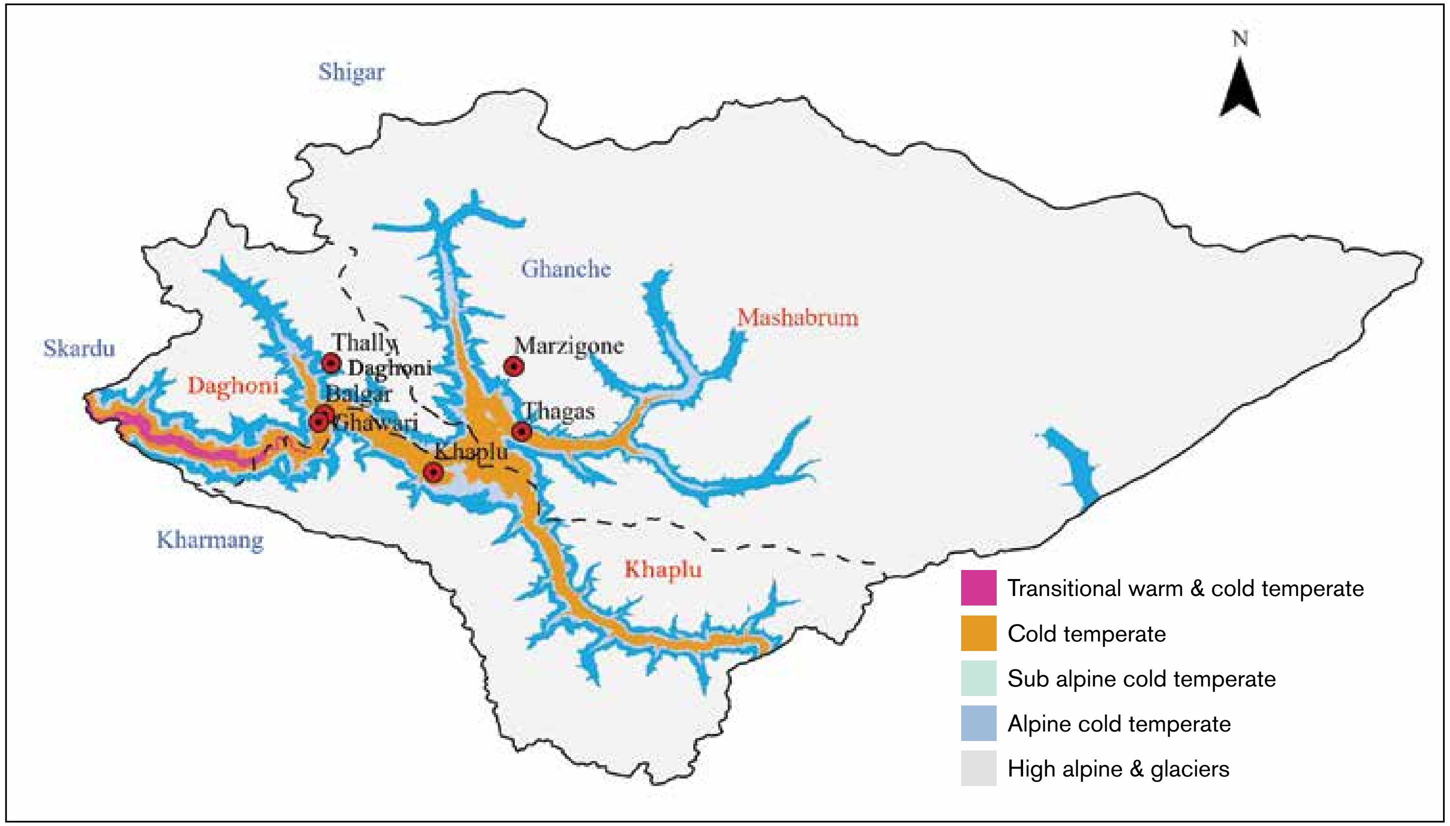
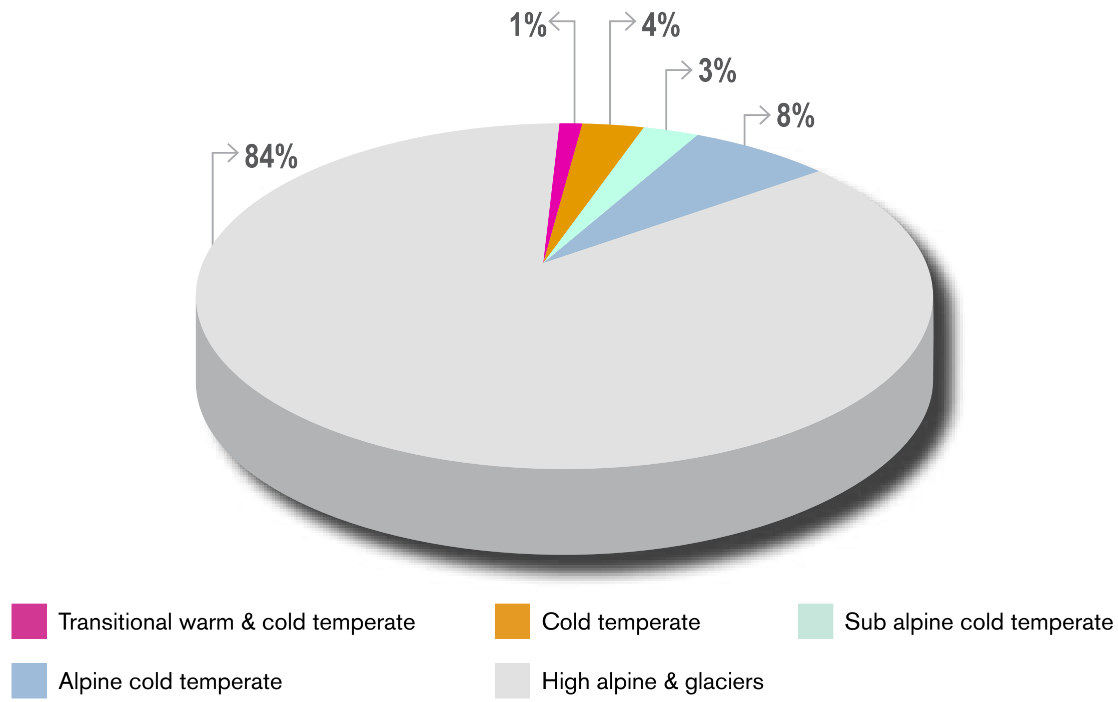


Table 7. Major locations falling in various AEZs

Agro-ecological zones	Major locations
Transitional Warm & Cold Temperate Alleviation: 7,000-8,000 feet (2,150-2,450 m) Avg. Temp.: 3.9°C Avg. Prec.: 419 mm	This zone is located in areas adjoining Skardu. Major locations include Keris, Ghowari, Kuru, Kharfaq, Daghoni Balghar, Yugo, Kharko, Barah.
Cold Temperate Alleviation: 8,000-9,500 feet (2,450-2,900 m) Avg. Temp.: 3.2°C Avg. Prec.: 441 mm	This zone prevails in all tehsils of the district. Major locations include Saling, Khaplu (lower), Ghursey, Surmo, Yuchung.
Sub Alpine Cold Temperate Alleviation: 9,500-10,500 feet (2,900-3,200 m) Avg. Temp.: -3.5°C Avg. Prec.: 339 mm	This zone is stretched in remote parts of district. Khaplu (upper), Happy, Gharbuchung, lower Thallay, lower Hushe, Surmo Broq, Thalis, Machulu, Balay Ghund.
Alpine Cold Temperate Alleviation: 10,500-12,500 feet (3,200-3,800 m) Avg. Temp.: -4.0 °C Avg. Prec.: 259 mm	This is the largest zone in Ghanche and is stretched further in remote parts of district in all tehsils. Hanjol, Ihly, upper Thallay, upper Hushe, Dumsum, Kudus, Saltoro, Goma, Gulshan-e-Kabir, Chorbut
High Alpine and Glaciers Alleviation: 12,500 feet + (3,800 m +) Avg. Temp.: -7.1°C Avg. Prec.: 227 mm	Areas above 3800 meters above sea level and higher. This is an aera which is only used as high-altitude pastures and not for crops.

Figure 3. Percentage area under various AEZs

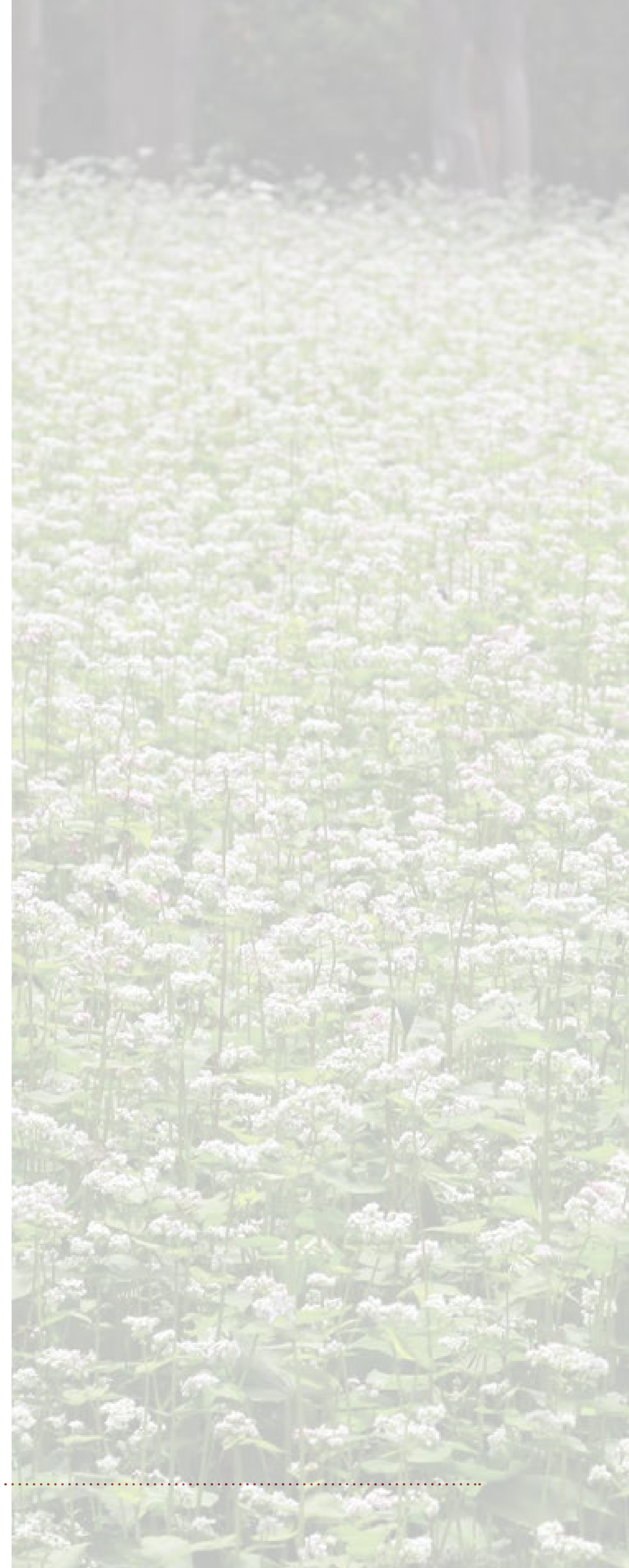


7. Agricultural potential

It is important to note that in an irrigated agriculture system with 4-5 months of summer, most crops may be grown in most of the zones except for the Alpine Cold Temperate zone where fruits and wheat do not ripe due to short growing season. However, some crops grow well in some zones compared to others. The recommendations therefore are based on what could grow well giving best yields, and not on which crops are grown at present. Ghanche is an ideal zone for certified seed / bulb production (onion, gladiola, lilium, tulips, daffodils). In addition to introducing an appropriate cropping pattern, soil fertility management and erosion control are imperative due to soil characteristics described earlier. The following potential has been identified after consultations with Agriculture Department and farming community as well as assessing the climate and market potential pertaining to various AEZs (**Table 8**).

Table 8. Potential of crops in various AEZs

Type	Potential crops	Remarks
Potential in Transitional Warm & Cold Temperate zone		
Cereals	Wheat (winter sowing only), barley, buckwheat	Wheat is only grown in spring and must shift to winter and save season for other high value crops in summer. Among cereals for summer or later in autumn, barley followed by buckwheat may be a good choice.
Vegetables	Potato, peas, tomato, onion, carrot, cabbage, red beans	Farmers may decide to either grow winter wheat or leave the land fallow during winter for cultivating different vegetables or potato in the spring. Potato harvesting may follow short duration vegetables e.g., peas. Red kidney beans may be cultivated on peripheries. Major vegetables in this zone include cauliflower, cabbage, tomato, garlic, and red beans. Tomato and cucumber are strongly suggested to be cultivated in vertical farming tunnels for greater benefit. Intercropping with cabbage or Chinese cabbage may increase per unit area production and cash return.
Fruit	Apple, apricot, cherry, walnut	Apple, apricot, cherry, and walnut are niche fruits of Ghanche with high economic gain. Apricot is high potential in Ghwari and Barah whereas cherry in Ghwari and Saling with seasonal advantage. Other fruits include grapes, peach, almond and pear. This zone of Ghanche also qualifies for bulb production for floriculture. This potential may be further upscaled in this zone in Ghanche.
Fodder	Barley / millet Alfalfa	Barley-millet for cereal and fodder Alfalfa intercropped with orchards
Potential in Cold Temperate zone		
Cereals	Barley, millet	It is highly recommended to discourage farmers for sowing spring wheat that occupy limited high value agricultural lands that may be better used for growing barley followed by millet or short duration vegetables for cash.
Vegetables	Potato, carrot, and broad beans	Potato is the most viable cash crop in this zone. Peas and pumpkin are niche vegetables. Other vegetables include tomato, radish, capsicum and cauliflower.
Fruit	Apricot and walnut	Apple, apricot, and walnut are significant in this zone. Other fruits including cherry, grapes, peach, almond and pear are also cultivated.
Fodder	Irrigated natural pastures and crop by-products	No specific cultivation
Potential in Sub Alpine Cold Temperate zone		
Cereals	Barley or buckwheat	Either barley or buckwheat may be cultivated in this zone due to short duration cultivation season
Vegetables	Potato, turnip, peas	Turnip and peas may be more suitable. Potato may be cultivated.
Fruit	Walnut and apricot	Walnut and apricot cultivation only for oil and fruit
Fodder	Natural pastures and crop by-products	No specific cultivation
Potential in Alpine Cold Temperate zone		
Cereals	Barley or buckwheat	The growing season in this zone is barely enough for barley for fodder or buckwheat.
Vegetables	None	The growing season in this zone is too short. Turnip is successfully cultivated in this little window. Potato is cultivated for home consumption only.
Fruit	None	Not suited for fruits.
Fodder	Natural pastures and crop by-products	No specific cultivation



Agro-Ecological Zones

Ghizer

Latitude 36.2797° N and Longitude 73.2765° E

1. Introduction

District Ghizer is situated in the Gilgit region. The district is spread over an area of 12,381 sq.km (1,238,100 Ha) which is 17% of the total area of Gilgit-Baltistan (GB)[1]. Ghizer is bounded by district Upper Chitral of Khyber Pakhtunkhwa on the North, district Hunza, district Nagar and district Gilgit on the East and district Diamer on the South-West. The district headquarter is the town of Gahkuch. Administratively, Ghizer is divided into four tehsils: Punial, Gupis, Yaseen and Ishkoman. The total population of the district in 2017 was 170,000 with 18,888 households at an average household size of 9[2] dwelling in 76[3] villages. With a growth rate of 1.84[4], the estimated population of the district is 186,226 persons in 2022. The overall literacy rate of the district is 64% - male 75%, female 54%[5].

2. Land use statistics

According to the Government of GB, the total agricultural land of the district is 17,582 hectares (ha) out of which 7,355 ha is cultivated and 10,227 ha is cultivable waste[6]. The land use statistics of district are given in **Table 1**.

Table 1. Land use statistics

S.No.	Type of Land	Area (Ha)	Percentage
1.	Agricultural Land	17,582	1.4%
2.	Forest Land	17,864	1.5%
3.	Range Land & Pastures	267,850	21.6%
4.	Rivers/Lakes	41,106	3.3%
5.	Built up Area	11,762	1%
6.	Snow/Glaciers	132,780	10.7%
7.	Rocks	732,766	59.2%
8.	Unaccounted for	16,390	1.3%
	Total	**1,238,100**	**100%**

Source: Calculated using GIS tools based on district shape files provided by GB Agriculture department 2022

3. Current features of agriculture

The cropping pattern in Ghizer is influenced by elevation which ranges from about 2275 meters (m) to 2743 m, and its climate. The sowing and harvesting season vary from zone to zone. Below 2438 m double cropping system is practised while above this altitude single cropping pattern is practiced. The major cereal crops of the district are wheat, maize, and barley. The vegetables grown are potato, tomato, peas, cabbage, cucumber, carrot, radish, okra, Leafy vegetables, and beans. The fruits of the district are apricot, cherry, apple, grapes, pomegranate, walnut, pear, and almond. Farmers also grow some fodder crops to feed their animal. Like other districts in the GB, farmers practice mixed farming since centuries as source of subsistence living. The typical cropping pattern followed in Ghizer is given in **Table 2**.

Table 2. Current cropping pattern

Altitude (m) and major locations (examples)	Cropping Pattern
Altitude: Below 2438 **Cropping Season:** Feb-Oct Double cropping zone **Major location:** Punial Valley: Gulabpur, Sherqila, Singul, Gulmuti, Bubur, Gahkuch, Hatoon, Golodas	• Winter: Wheat • Summer: Maize – OR • Potato followed by vegetables of all kind and fodder on small area. • Vegetables and fodder on small area parallel to crops • Fruits (Apricot, Apple, Cherry, Grapes, peaches etc. • Fodder is also grown as irrigated perineal crop
Altitude: 2438 to below 2743 **Cropping Season:** Mar-Oct Single cropping zone **Major location:** Gupis, lower Yasin Valley, Chatorkan Valley	• Spring wheat followed by barley or maize or buckwheat on small scale OR • Potato followed by peas, vegetables, and fodder • Vegetable on small scale parallel to crops • Fruits (Apricot, apple, Cherries, walnut, almond) • Fodder is also grown as irrigated perineal crop
Altitude: Above 2743 **Cropping season:** April-Sep Single cropping zone **Major location:** Upper Yasin valley, Phandar and Teru, Ishkoman Valley, Immit Valley	• Potato, with vegetable and fodder – OR • Spring wheat, with vegetable and fodder – OR • Barley with vegetable and fodder – OR • Maize only • Fruits (Apple, Cherries, and limited Apricots especially in high altitude areas). • Fodder is also grown as irrigated perineal crop

Source: Primary data from district consultation workshops and interviews June 2022

[1] GB at a glance 2020. Government of Gilgit Baltistan
[2] Ibid
[3] Agriculture Statistics Report 2014. Gilgit Baltistan
[4] https://www.citypopulation.de/en/pakistan/cities/gilgitbaltistan
[5] GB at a Glance 2020. Government of Gilgit Baltistan
[6] Agriculture Census 2020, department of Agriculture Gilgit Baltistan

4. Soil characteristics

Soil characteristics of Ghizer are dominated by parent material which is Lithosols characterised by coarse textured un-weathered or partly weathered rock fragments, usually found on steep slopes. Soil is generally shallow. Lithosols are highly prone to land degradation and cannot support sustainable crop production without strong efforts for conservation. If this shallow soil is lost, it will be a long weathering process before new soil is formed. Gleysols is minority soil located on borders with Chitral with slightly acidic to neutral pH. Silty loam was the predominant soil texture found in Ghizer with the major class of Lithomorphic soils occupying the district. Potassium is marginal to adequate but still requires proper management for agriculture production. A summary of soil characteristics is provided in **Table 3**:

Table 3. Summary of soil characteristics

Parent material	Organic Matter (%)	Fertility			Soil texture			pH
		NO3-N (mg kg^{-1})	P (mg kg^{-1})	K (mg kg^{-1})				
Lithosols 90% Gleysols 10%	Marginal	Low	Low	Adequate	Silty loam 50%	Clay loam / loam 30%	Silty clay loam 20%	Neutral to Alkaline in most of the district. Slightly Acidic to neutral in few areas closer to Chitral.

5. Climate trends

A major increase in temperature has happened in the past 30 years. The average day time temperature has increased from 6.2°C to7.8°C, which is an increase of 1.6°C since 1991. Overall, a major increase is in the Spring season.

The average night temperature has increased from -4.7°C to -3.5°C which is an increase of 1.2°C since 1991. The nights are becoming warmer in all the months at a faster rate than the days. Due to warmer springs and autumn, the crop growing season is expanding providing an opportunity to the farmers to convert some of the areas into double cropping zone or introduce longer duration crops in single cropping zones. In spring season, more water will be available due to early onset of snowmelt due to increased temperatures. The increasing temperature during spring allows little time for snow to consolidate. Early snowmelt may result in flash floods during spring season. Due to increased temperature in September and October, autumn is becoming milder and starts late. There is possibility of expanding the cropping season by early sowing in spring and late harvests in autumn thus bringing the possibility of additional short duration crops in the current single cropping areas.

Precipitation pattern has not changed much in Ghizer. Slightly more snow is received than rains during autumn. Precipitation increased between 1960 and 1990 but then it has started declining since 1991. With increasing temperatures during spring and summers and reduced rains, farmers' dependence on irrigation will increase.

Following sub sections provide details on day and night temperatures (**Tables 4 and 5**), and precipitation (**Table 6**). These analyses are based on average conditions. There may be year to year variations (e.g., cold wave during spring, or wetter than average or drier than average). This climate variability is not accounted for in ascertaining climate change trend.

5.1 Analysis of maximum temperature

- Mean monthly day time temperature during the winter months is overall increasing. A major change is in the months of January and February. In case of December the temperature had increased after 1960 but since 1991 it is showing a declining trend.
- Day temperatures in spring season are also increasing. The largest increase is noted in the months of March, i.e., 2.2°C since 1991.
- Day temperatures in summers have increased since 1991 to varying degrees with maximum increase recorded in July.
- Day time temperatures in autumn are increasing for October but decreasing in November.

Table 4. Trend analysis of mean monthly maximum temperature (°C)

	1960-2020			1960-1990			1991-2020		
Months	Change from – to	Change in temperature	Trend	Change from - to	Change in temperature	Trend	Change from - to	Change in temperature	Trend
Dec	-4.2 to -3.9	0.3	↑	-4.7 to -3.7	1	↑	-3.5 to -4.4	-0.9	↓
Jan	-7.2 to -6.6	0.6	↑	-7.3 to -6.6	0.7	↑	-7.4 to -6.4	1	↑
Feb	-6 to -4.9	1.1	↑	-5.7 to -5.9	-0.2	↓	-5.3 to -4.9	0.4	↑
Mar	-0.9 to 0.6	1.5	↑	0 to -1	-1	↓	-0.8 to 1.4	2.2	↑
Apr	5.3 to 6.7	1.4	↑	5 to 6.6	1.6	↑	5.5 to 6.9	1.4	↑
May	9.5 to 10.5	1	↑	9.3 to 10.3	1	↑	9.6 to 10.8	1.2	↑
Jun	15.1 to 14.9	-0.2	↓	15.2 to 15	-0.2	↓	14.5 to 15.3	0.8	↑
Jul	18.2 to 18.6	0.4	↑	18.2 to 18.6	0.4	↑	17.9 to 18.9	1	↑
Aug	18.2 to 18.2	0	↔	18.2 to 18.3	0.1	↑	18 to 18.3	0.3	↑
Sep	14.7 to 15.3	0.6	↑	14.4 to 15.5	1.1	↑	14.8 to 15.3	0.5	↑
Oct	8.5 to 9.1	0.6	↑	8.5 to 8.8	0.3	↓	8.6 to 9.3	0.7	↑
Nov	1.6 to 2.5	0.9	↑	0.9 to 2.7	1.8	↑	2.9 to 1.7	-1.2	↓

5.2 Analysis of minimum temperature

- Mean monthly night temperatures during winter months are overall increasing in the last 30 years. During the period from 1960 this increase was noted between 1.1 and 1.5°C.

The night temperatures for December which were increasing between 1960-1990, are showing a declining trend since 1991.

- The increase in night temperatures is more when compared to day temperatures in the spring months. As a result, springs will be warmer and early onset of spring will be witnessed. This may allow farmers early sowing of crops.
- Summer nights are also becoming warmer. A maximum change observed is in the month of September.
- As in case of other seasons, similar warming trend is observed in autumn with the highest increase in October.

Table 5. Trend analysis of mean monthly minimum temperature (°C)

	1960-2020			1960-1990			1991-2020		
Months	Change from – to	Change in temperature	Trend	Change from – to	Change in temperature	Trend	Change from – to	Change in temperature	Trend
Dec	-13.2 to -12.1	1.1	↑	-14 to -11.7	2.3	↑	-11.9 to -12.8	-0.9	↓
Jan	-16.4 to -14.9	1.5	↑	-16.8 to -15.1	1.7	↑	-15.8 to -14.9	0.9	↑
Feb	-15.1 to -13.6	1.5	↑	-14.7 to -14.9	-0.2	↓	-14.2 to -13.6	0.6	↑
Mar	-10.2 to -8	2.2	↑	-9.8 to -9.3	0.5	↑	-9.6 to -7.4	2.2	↑
Apr	-4.9 to -3.2	1.7	↑	-4.9 to -3.9	1	↑	-4.6 to -2.8	1.8	↑
May	-2 to 0.1	2.1	↑	-2 to -0.8	1.2	↑	-1.3 to 0.2	1.5	↑
Jun	2.5 to 3.3	0.8	↑	2.6 to 2.9	0.3	↑	2.6 to 3.5	0.9	↑
Jul	5.5 to 6.6	1.1	↑	5.6 to 5.9	0.3	↑	5.4 to 7	1.6	↑
Aug	5.1 to 6.4	1.3	↑	5.3 to 5.8	0.5	↑	5.2 to 6.9	1.7	↑
Sep	0.7 to 2.2	1.5	↑	1 to 1.3	0.3	↑	0.9 to 2.7	1.8	↑
Oct	-4.5 to -2.8	1.7	↑	-4.2 to -3.7	-0.5	↓	-4.2 to -2.3	1.9	↑
Nov	-9.2 to -8.3	0.9	↑	-9.6 to -8.2	1.4	↑	-8.6 to -8.6	0	↔

5.3 Analysis of precipitation

Overall, annual precipitation has reduced a little since 1960 but this reduction has been observed since 1991. A major reduction is observed during spring and summer months.

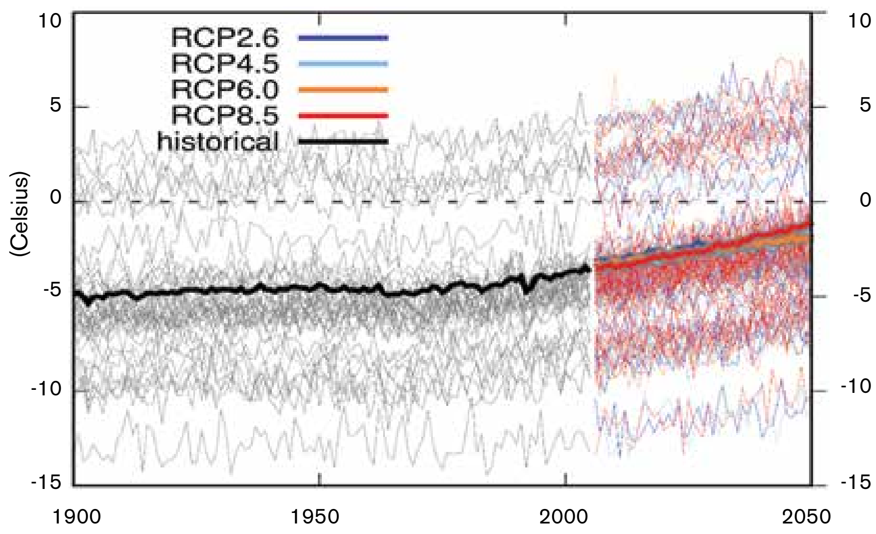
Table 6. Trend analysis of annual and seasonal precipitation (mm)

	1960-2020			1960-1990			1991-2020		
Season	Change from – to	Change in precipitation	Trend	Change from – to	Change in precipitation	Trend	Change from – to	Change in precipitation	Trend
Annual	398 to 396	-2	↓	392 to 403	11	↑	408 to 386	-22	↓
Winter	108 to122	14	↑	106 to 116	10	↑	118 to 118	0	↔
Spring	174 to 138	-36	↓	178 to 146	-32	↓	158 to 138	-20	↓
Summers	74 to 92	18	↑	66 to 92	26	↑	98 to 79	-19	↓
Autumn	44 to 44	0	↔	44 to 47	3	↑	34 to 49	15	↑

5.4 Climate scenarios

Figure 1 with near surface temperature presents projections till 2050 based on different GHG emissions scenarios and how these emissions will affect the temperature in Ghizer. Taking the historical trend from 1900 time series given in Figure 1 projects that under different scenarios the mean temperature of Ghizer will be between -2°C and -1°C which at the turn of the century was around -5°C. This is a raise of 3°C to 4°C by 2050.

Figure 1. Temperature projection till 2050



Source: IPCC Assessment Report 5 – 2014

6. Agro-ecological zones

Ghizer is one of four districts where all Agro-ecological zones (AEZs) are prevalent. The first Hot & Cold Temperate zone has just started to set in, in eastern Ghizer (Biarchi Gulabpur). The area is very small due to which difficult to see on the AEZs map (**Figure 2**) and in the chart showing percentage of zones (**Figure 3**). Other six agro-ecological zones are more prominent with large agricultural diversity. Figure 2 is supported by **Table 7** with major locations falling in various zones. As a whole, 31% of the district area falls under cultivable category whereas 69% district is beyond agricultural potential.

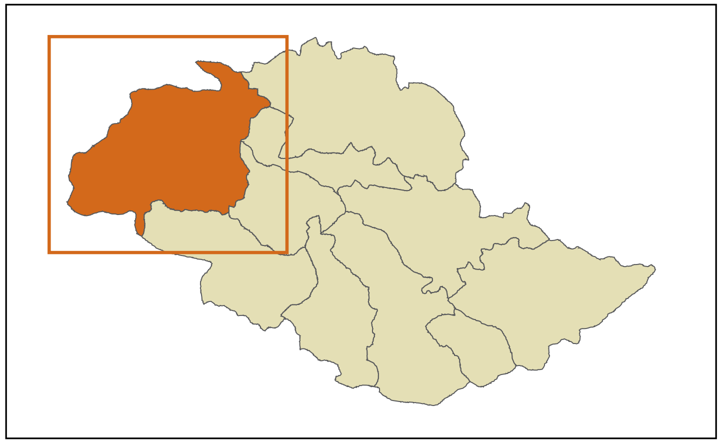


Figure 2. Agroecological zones of Ghizer District

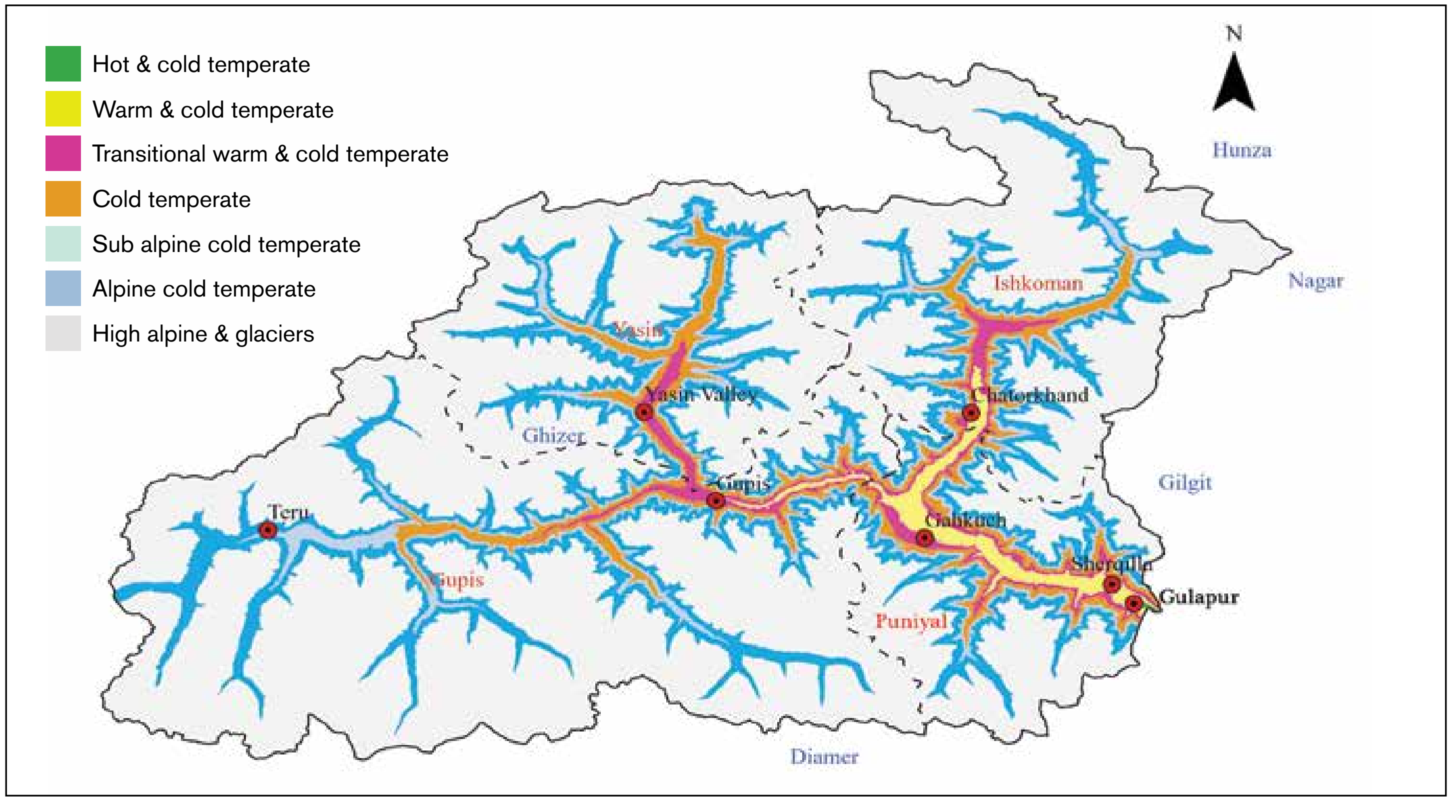
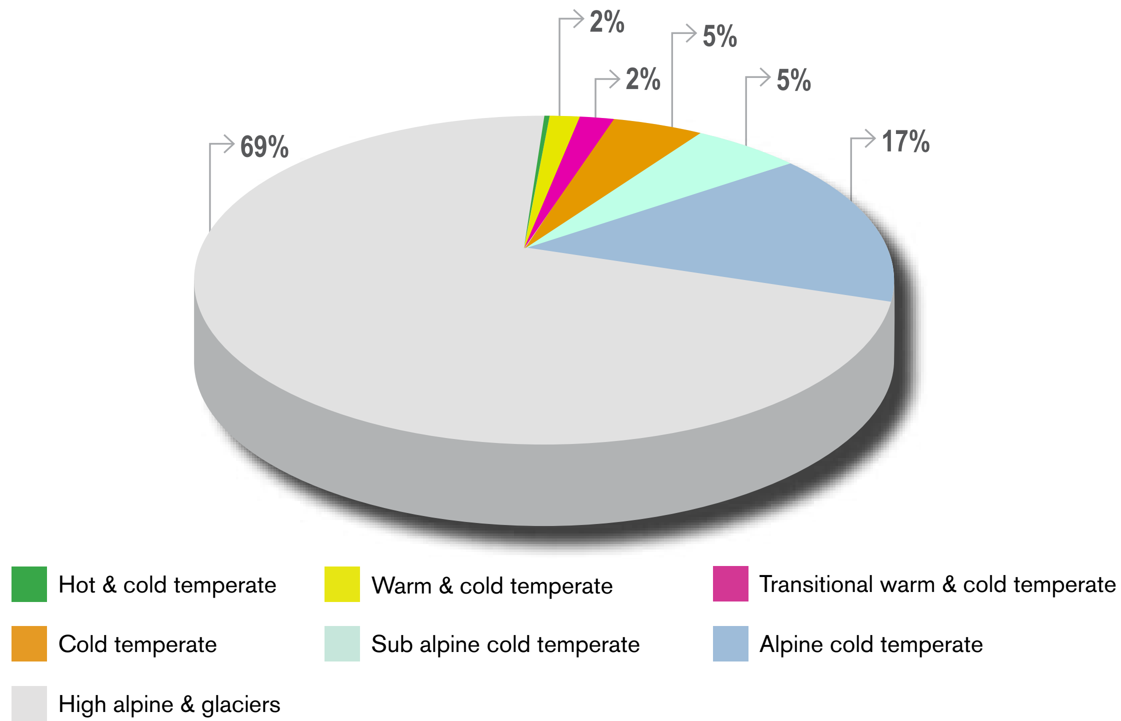


Table 7. Major locations falling in various AEZs

Agro-ecological zones	Major locations
Hot & Cold Temperate Alleviation: 4,000-5,500 feet (1,220-1,700 m) Avg. Temp.: 4.5°C Avg. Prec.: 427 mm	This zone is just developing in Ghizer at the location of periphery of Gulabpur bordering Gilgit. It is too small to be included in further analysis.
Warm & Cold Temperate Alleviation: 5,500-7,000 feet (1,720-2,150 m) Avg. Temp.: 4.4°C Avg. Prec.: 389 mm	This zone contiguously thrives in areas bordering Gilgit in Punial and continues to parts of Ishkoman and Gupis. Major locations include Single, Sher Qila, Gulabpur, Gulodas, Chatorkhand, Bubur, Hasis, Small, Jaj Bargu, Raushan
Transitional Warm & Cold Temperate Alleviation: 7,000-8,000 feet (2,150-2,450 m) Avg. Temp.: 3.9°C Avg. Prec.: 419 mm	This zone prevails in Yasin and Ishkoman but also in Gupis and Punial. Major locations include main Gupis, Damalgal, Main Ishkoman, Bar Jungle, Imit, Gindai, Proper Yasin, Sultanabad, Taus, Dahimal and Khalti.
Cold Temperate Alleviation: 8,000-9,500 feet (2,450-2,900 m) Avg. Temp.: 3.2°C Avg. Prec.: 441 mm	This zone is spread over a larger area in the following locations: Phandar lower, Pingal, Chashi, Upper Ishkoman, upper Yasin (Nazbar, Thoi, Barkolti).
Sub Alpine Cold Temperate Alleviation: 9,500-10,500 feet (2,900-3,200 m) Avg. Temp.: -3.5°C Avg. Prec.: 339 mm	This zone is located on higher elevations along Cold Temperate zone. It includes Darkut, Upper Phandar, Handrup and Teru.
Alpine Cold Temperate Alleviation: 10,500-12,500 feet (3,200-3,800 m) Avg. Temp.: -4.0 °C Avg. Prec.: 259 mm	This zone is located on a large stretch at a higher elevation along Sub Alpine Cold Temperate zone. One of the locations is Teru upper but most of the higher elevation pastures of earlier mentioned locations.
High Alpine and Glaciers Alleviation: 12,500 feet + (3,800 m +) Avg. Temp.: -7.1 °C Avg. Prec.: 227 mm	3800 meters above sea level and higher. This is an area which is only used as high-altitude pastures.

Figure 3. Percentage area under various AEZs



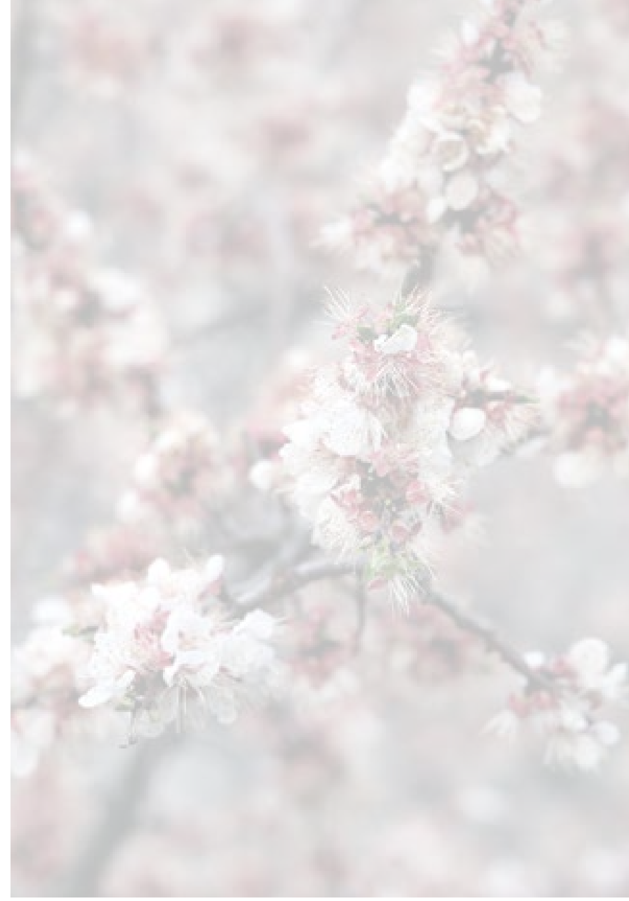
7. Agricultural potential

The following potential (**Table 8**) has been identified in consultations with Agriculture Department and the farming community as well as assessing the climate and market potential pertaining to various AEZs of the district. In addition to introducing an appropriate cropping pattern, soil fertility management and erosion control are imperative in Ghizer due to soil characteristics described earlier.

Table 8. Potential of crops in various AEZs

Type	Potential crops	Remarks
		Potential in Hot & Cold Temperate zone
Cereals	Wheat (winter), Maize	Less than 0.2% area covered by this zone. Therefore, no distinct cropping system has been identified for this area. It is, therefore, paired with Warm & Cold Temperate zone.
Vegetables	Capsicum, cucumber, peas, tomato	
Fruit	Apple, grapes, pomegranate, cherry, apricot	
Fodder	Berseem, Alfalfa	
		Potential in Warm & Cold Temperate zone
Cereals	Wheat (winter), Maize	Wheat (winter) and maize are suitable in this zone.
Vegetables	Capsicum, cucumber, peas, tomato, potato,	Tomato is high potential in this zone and already enjoying a successful market. Onion and capsicum are also highly successful. In addition, cucumber, tomato and other suitable vegetables are recommended to be cultivated in vertical farming tunnels for greater benefit in limited space.
Fruit	Apple, cherry, apricot, almond	Top priority fruits in this zone are grapes, pomegranate, almond and apricot.
Fodder	Barley, Alfalfa	Both berseem and alfalfa are cultivated in the field for fodder
		Potential in Transitional Warm & Cold Temperate zone
Cereals	Maize and wheat (winter only)	Maize is the main cereal crop. Subsistence cultivation of spring wheat takes place to ensure food security. Due to temperature increase, winter wheat may be successful in this zone. With the introduction of high yielding varieties, wheat crop can be an economic crop while with the improvement in communication infrastructure, it is recommended to use this area as high potential for vegetable and fruit production.
Vegetables	Potato, tomato, turnip, onion, carrot, cabbage	Potato is a major crop in this zone followed by turnip and cabbage. Carrot and onion are also a high potential crop in this zone. Cucumber and tomato are proposed in vertical farming, with cabbage intercropping (or separately in the field).
Fruit	Apricot, Apple, cherry	Apricot is a top fruit in this zone beside apple and cherry. Apricot is cultivated to produce dried fruit rather than fresh. Beside these, almond and walnut are also very successful.
Fodder	Barley / Alfalfa	Barley is cultivated at a subsistence level including for fodder. Alfalfa is cultivated separately as well as intercropped with maize.
		Potential in Cold Temperate zone
Cereals	Discourage spring Wheat	This is spring wheat sowing zone. However, since land is highly limited, it is recommended to save land for marketable vegetable crops instead of spring wheat. Barley is cultivated in this zone for fodder.
Vegetables	Potato (including seed potato), peas, carrot, turnip	Potato (table and seed) and peas are highly viable cash crops in this zone. This zone is also suitable for producing carrot, turnip, cabbage, and radish. In addition, there is a high potential for cultivating faba beans on the peripheries or as intercropping in the orchards. Cucumber and tomato are proposed in vertical farming (or separately in the field).

Fruit	Pear, apple, walnut	Quality of these fruits is very good in this zone in Ghizer.
Fodder	Barley, alfalfa	Barley is cultivated for fodder. Alfalfa is cultivated in open fields and marginal land/slopes
Potential in Sub Alpine Cold Temperate zone		
Cereals	None	Economic potential of wheat when compared to vegetables is very low and not recommended. It is recommended to use this area as high potential for vegetable production if sustainable market is ensured.
Vegetables	Potato, peas, turnip and carrot	Potato (table and seed), peas and turnip are successful cash crop in this zone. Carrot is also successful.
Fruit	None	Not suited for fruit trees
Fodder	Natural pastures and crop by-product	No specific cultivation
Potential in Alpine Cold Temperate zone		
Cereals	None	Too cold for cereals
Vegetables	Peas, turnip	The growing season is too short and just suited for short duration off season turnip and peas.
Fruit	None	Not suited for cultivating trees
Fodder	Natural pastures and crop by-product	No specific cultivation



Agro-Ecological Zones

Gilgit

Latitude 35.8819° N and Longitude 74.4643° E

1. Introduction

Gilgit District is the provincial capital of Gilgit-Baltistan (GB). The district is spread over an area of 4,208 sq.km (420,800 ha) which is 6% of the total area of GB[1]. Gilgit is bounded on the north by district Nagar, on the east by districts Shigar and Skardu, on the south by districts Diamer and Astore and on the west by district Ghizer. The district headquarter is the town of Gilgit. Administratively Gilgit district is composed of three tehsils: Danyor, Juglot and Gilgit. The population of the district in 2017 was 290,000 with 35,803 households at an average household size of 8.1[2] dwelling in 42[3] villages. With a growth rate of 3.7[4], the estimated population of the district in 2022 is 347,770. This is the third highest population growth recorded in GB after Diamer and Skardu. The overall literacy rate of the district is 67% - male 78%, female 57%[5].

2. Land use statistics

According to the Agriculture Department GB, the total agricultural land of the district is 7,758 ha. Out of which 3,721 ha is cultivated and 4,037 ha is cultivable waste[6]. The land use statistics of district Gilgit are given in **Table 1**.

Table 1. Land use statistics

S.No.	Type of Land	Area (Ha)	Percentage
1.	Agricultural Land	7,758	1.9%
2.	Forest Land	27,087	6.4%
3.	Range Land & Pastures	120,366	28.6%
4.	Rivers/Lakes	15,293	3.6%
5.	Built up Area	5,176	1.2%
6.	Snow/Glaciers	57,008	13.6%
7.	Rocks	167,088	39.7%
8.	Unaccounted for	21,022	5%
	Total	**420,800**	**100%**

Source: Calculated using GIS tools based on district shape files provided by GB Agriculture department 2022

3. Current features of agriculture

The current cropping pattern in Gilgit is influenced by the elevation which ranges from about 1250 meters to above 3000 meters as sowing and harvesting of crops vary from zone to zone. Below 2000 meters, double cropping system is practiced, whereas single cropping pattern is practiced in valleys at higher altitudes. The major cereal crops are wheat, maize, and barley. Potato is main cash crop especially in high altitude valleys while main vegetables grown are tomato, peas, cabbage, cucumber, carrot, turnip, and beans. Major fruits are apricot, cherry, apple, grapes, pear, peaches, persimmon, pomegranate, mulberry, walnut, and almond. It is important to mention that farmers practice mixed farming for subsistence. A typical cropping pattern practiced in district Gilgit is depicted in **Table 2**.

Table 2. Current cropping pattern

Altitude (m) and major locations (examples)	Cropping pattern
Altitude: Below 2000 **Cropping season:** Feb – Oct Double cropping **Major locations:** Rahimabad, Oshkendas, Jutal, Sultanabad, Nomal, Jalalabad, Goru Juglot, 30% area of Bugrot (Sinakir and Hamaran villages), Bisin, Sharot, Bargo, Sai Juglot, Haramosh (village Khaltaro), lower Naltar	• Winter wheat followed by maize or vegetables – OR • Potato followed by maize or vegetables or fodder – OR • Vegetables followed by maize or vegetables and fodder – OR • Barley followed by maize or with vegetables and fodder • Temperate fruits varieties are grown on large scale in orchards and scattered tree plantation • Fodder as irrigated perineal crop on limited scale
Altitude: Above 2000 **Cropping season:** Feb – Sep Single cropping **Major locations:** Bugrot 70% area (Datoche, Harpu, Opaei, Bilchar, Chira), Upper Haramosh, Naltar, Kargah	• Spring wheat followed by vegetables and maize (fodder) – OR • Barley followed by potato with vegetable and fodder – OR • Potato followed by vegetables and fodder – OR • Maize – fallow – OR • Wheat – fallow – OR • Potato – fallow • Major temperate fruit varieties are grown at lower altitude which diminish with altitude

Source: Primary data from district consultation workshops and interviews June 2022

[1] GB at a glance 2020. Government of Gilgit Baltistan
[2] Ibid
[3] Agriculture Statistics Report 2014. Gilgit Baltistan
[4] https://www.citypopulation.de/en/pakistan/cities/gilgitbaltistan
[5] GB at a Glance 2020. Government of Gilgit Baltistan
[6] Agriculture Census 2020, department of Agriculture Gilgit Baltistan

4. Soil characteristics

Soil characteristics of Gilgit are dominated by parent material which is mainly Lithosols characterised by coarse textured un-weathered or partly weathered rock fragments, usually found on steep slopes. Soil is generally shallow, around 30 cm in depth. Lithosols are highly prone to land erosion and degradation and therefore sustainable crop production is only possible with strong efforts for conservation. If this shallow soil is lost, it will be a long weathering process before new soil is formed. Gleysols is found in areas bordering Nagar district.

Silty clay loam is the predominant soil texture in Gilgit with the major class of Lithomorphic soils occupying the district. Potassium in soils is marginal and requires proper management for agriculture production. A summary of soil characteristics is provided in **Table 3**.

Table 3. Summary of soil characteristics

Parent material	Organic Matter (%)	Fertility			Soil texture		pH
		NO3-N (mg kg^{-1})	P (mg kg^{-1})	K (mg kg^{-1})			
Lithosols 90% Gleysols 10%	Marginal	Low	Low	Marginal	Silty clay loam 90%	Silt loam 10%	Neutral to Alkaline in most of the district. Slightly Acidic to neutral in few areas adjoining Astore / Diamer.

5. Climate trends

The average day temperature in Gilgit has increased from 8.15°C to 8.8°C in thirty years since 1991. This is an average increase of 0.65°C. The largest increase in day temperatures is noted in the spring season. The nights are becoming warmer in all the months at a faster rate than the days. The average night temperature has increased from -3.05°C to -1.7°C since 1991. The most notable ones are in the months of October, April, March, August, and September, all recording an increase of more than 2°C. Increased temperatures in January, February may result in early onset of spring. This may allow farmers early sowing of crops. The temperatures warm up rather quickly that may not allow snow to consolidate. Early snowmelt may cause flash floods during spring season. Due to increased temperature in September and October, the autumn is starting late and becoming milder. It can be concluded that summers are starting earlier and stretching into autumn and the winter season is reducing.

The annual precipitation is decreasing since 1991 which was earlier showing an increasing trend in the period between 1960 and 1990. Precipitation is reducing for all the seasons except autumn since 1991 due to early snowfall at the end of autumn on higher elevations. Reduction in precipitation may dry up springs posing a challenge to farming where irrigation water source is springs.

Following sub sections provide details on day and night temperatures (**Tables 4 and 5**), and precipitation (**Table 6**). Analysis in these sections is based on average conditions. There may be year to year variations (e.g., cold wave during spring, or wetter than average or drier than average). This climate variability is not accounted for in ascertaining climate change trend.

5.1 Analysis of maximum temperature

- Mean monthly day time temperature during winter months is overall increasing. The major change is in the months of January and February. Temperature in December increased after 1960 till 1990, but started to decrease after 1991.
- Day temperatures in spring season are also increasing. The largest increase is in the month of March by 2.1°C since 1991.
- Day temperatures in summers have increased since 1991 to varying degrees with maximum increase recorded in June and July.
- Day time temperatures in autumn are increasing for October but decreasing in November with occasionally early snowfall.

Table 4. Trend analysis of mean monthly maximum temperature (°C)

	1960-2020			1960-1990			1991-2020		
Months	Change from - to	Change in temperature	Trend	Change from - to	Change in temperature	Trend	Change from - to	Change in temperature	Trend
Dec	-2.4 to -1.9	0.5	↑	-2.7 to -1.9	0.8	↑	-1.7 to -2.3	-0.6	↓
Jan	-5.2 to -5	0.2	↑	-5.4 to -4.5	0.9	↑	-5.6 to -4.7	0.9	↑
Feb	-4 to -2.7	1.3	↑	-3.8 to -3.8	0	↔	-3.1 to -2.8	0.3	↑
Mar	1.6 to 3.1	1.5	↑	2.6 to 1.4	-1.2	↓	1.7 to 3.8	2.1	↑
Apr	7.7 to 9.2	1.5	↑	7.6 to 8.6	1	↑	7.8 to 9.6	1.8	↑
May	11.7 to 12.7	1	↑	11.6 to 12.5	0.9	↑	11.8 to 12.8	1	↑
Jun	17.1 to 16.6	-0.5	↓	17.3 to 16.7	-0.6	↓	16.4 to 17	0.6	↑
Jul	20 to 20	0	↔	20.1 to 20.1	0	↔	19.7 to 20.3	0.6	↑
Aug	19.7 to 19.4	-0.3	↓	19.6 to 19.6	0	↔	19.3 to 19.5	0.2	↑
Sep	16.5 to 16.7	0.2	↑	16.3 to 17	0.7	↑	16.3 to 16.8	0.5	↑
Oct	10.4 to 11.1	0.7	↑	10.6 to 10.5	-0.1	↓	10.3 to 11.4	1.1	↑
Nov	3.5 to 4.7	1.2	↑	3.1 to 4.5	1.4	↑	4.8 to 4.1	-0.7	↓

5.2 Analysis of minimum temperature

- Mean monthly night temperatures during the winter months are overall increasing during the last 30 years except in December which is showing declining trend. Since 1960 this increase was noted between 1.4 and 1.6°C.

- The increase in night temperatures is higher when compared to day temperatures in the spring months resulting in warmer springs.
- Summer nights are also becoming warmer. A maximum change was observed in the months of August and September. The temperatures for summer months were reducing during the period of 1960 – 1990 which have increased at a very fast rate between 1991 – 2020.
- Similar warming trend is observed in autumn with the highest increase in October. Autumn is starting late and becoming milder.

Table 5. Trend analysis of mean monthly minimum temperature (°C)

	1960-2020			1960-1990			1991-2020		
Months	Change from – to	Change in temperature	Trend	Change from - to	Change in temperature	Trend	Change from - to	Change in temperature	Trend
Dec	-11.9 to -10.4	1.5	↑	-12.5 to -10.5	2	↑	-10.4 to -11.1	-0.7	↓
Jan	-14.6 to -13.2	1.4	↑	-15 to -13.3	1.7	↑	-13.9 to -13.3	0.6	↑
Feb	-13.2 to -11.6	1.6	↑	-12.8 to -13	-0.2	↓	-12.3 to -11.5	0.8	↑
Mar	-8.2 to -6.1	2.1	↑	-7.7 to -7.5	-0.2	↓	-7.6 to -5.4	2.2	↑
Apr	-3.2 to -1.2	2	↑	-3 to -2.2	0.8	↑	-2.9 to -0.6	2.3	↑
May	-0.4 to 1.8	2.2	↑	-0.4 to 0.8	0.4	↑	0.3 to 2	1.7	↑
Jun	4.3 to 5.1	0.8	↑	4.6 to 4.3	-0.3	↓	4.3 to 5.4	1.1	↑
Jul	7.2 to 8.2	1	↑	7.7 to 7.4	-0.3	↓	7.2 to 8.8	1.6	↑
Aug	6.7 to 8	1.3	↑	7.1 to 7.1	0	↔	6.7 to 8.6	2.1	↑
Sep	2.4 to 3.7	1.3	↑	2.8 to 2.6	-0.2	↓	2.4 to 4.4	2	↑
Oct	-3.1 to -1.2	1.9	↑	-2.6 to -2.6	0	↔	-2.9 to -0.5	2.4	↑
Nov	-8 to -6.8	1.2	↑	-8.2 to -7.1	1.1	↑	-7.5 to -6.8	0.7	↑

5.3 Analysis of precipitation

- Precipitation in winter increased slightly since 1960 but declined since 1991.
- Spring precipitation consistently declined since 1960.
- Precipitation in summers increased since 1960, which however decreased since 1991.
- Precipitation in autumn has increased since 1991.

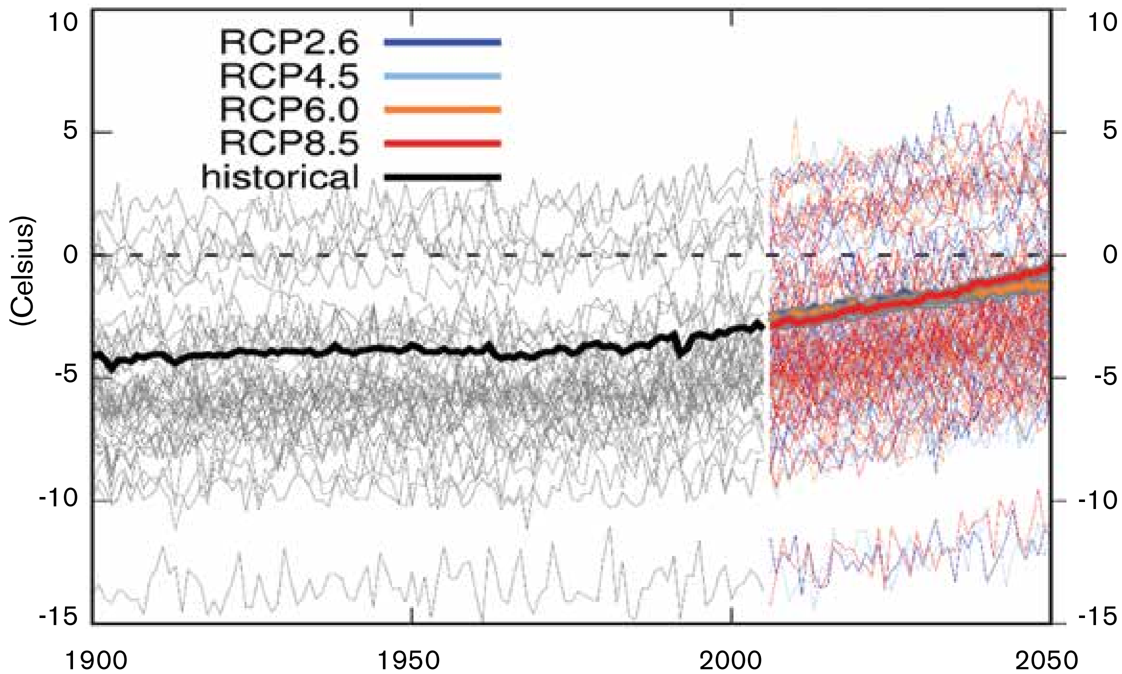
Table 6. Trend analysis of annual and seasonal precipitation (mm)

	1960-2020			1960-1990			1991-2020		
Months	Change from - to	Change in precipitation	Trend	Change from - to	Change in precipitation	Trend	Change from - to mm	Change in precipitation	Trend
Annual	350 to 350	0	↔	335 to 360	25	↑	360 to 340	-20	↓
Winter	84 to 97	13	↑	81 to 95	14	↑	95 to 92	-3	↓
Spring	149 to 122	-27	↓	154 to 127	-27	↓	139 to 122	-17	↓
Summers	83 to 105	22	↑	75 to 104	29	↑	105 to 96	-9	
Autumn	31 to 27	-4	↓	27 to 37	10	↑	23 to 31	8	↑

5.4 Climate scenarios

Figure 1 provides projection for temperature in Gilgit district till 2050. The projections are based on different GHG emissions scenarios and how these emissions will affect the temperature in Gilgit. Taking the historical trend from 1900, the time series projects that under different GHG emissions reduction scenarios, the mean near surface temperature of Gilgit will be between -2°C and -0.5°C which was around -4°C in 1900. This is a rise of about 2°C to 2.5°C since 1900.

Figure 1. Temperature projection till 2050



Source: IPCC Assessment Report 5 – 2014

6. Agro-ecological zones

Gilgit is one of four districts with Astore, Diamer and Ghizer where all Agro-ecological zones (AEZs) prevail. This can be a management challenge as well as an opportunity for agricultural diversity. **Figure 2** presents AEZs map which is supported by **Table 7** with major locations falling in various zones. **Figure 3** presents percentage of each zone prevalent in the district.

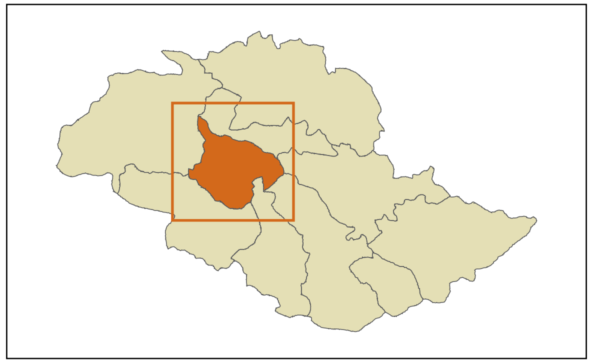


Figure 2. Agroecological zones of Gilgit District

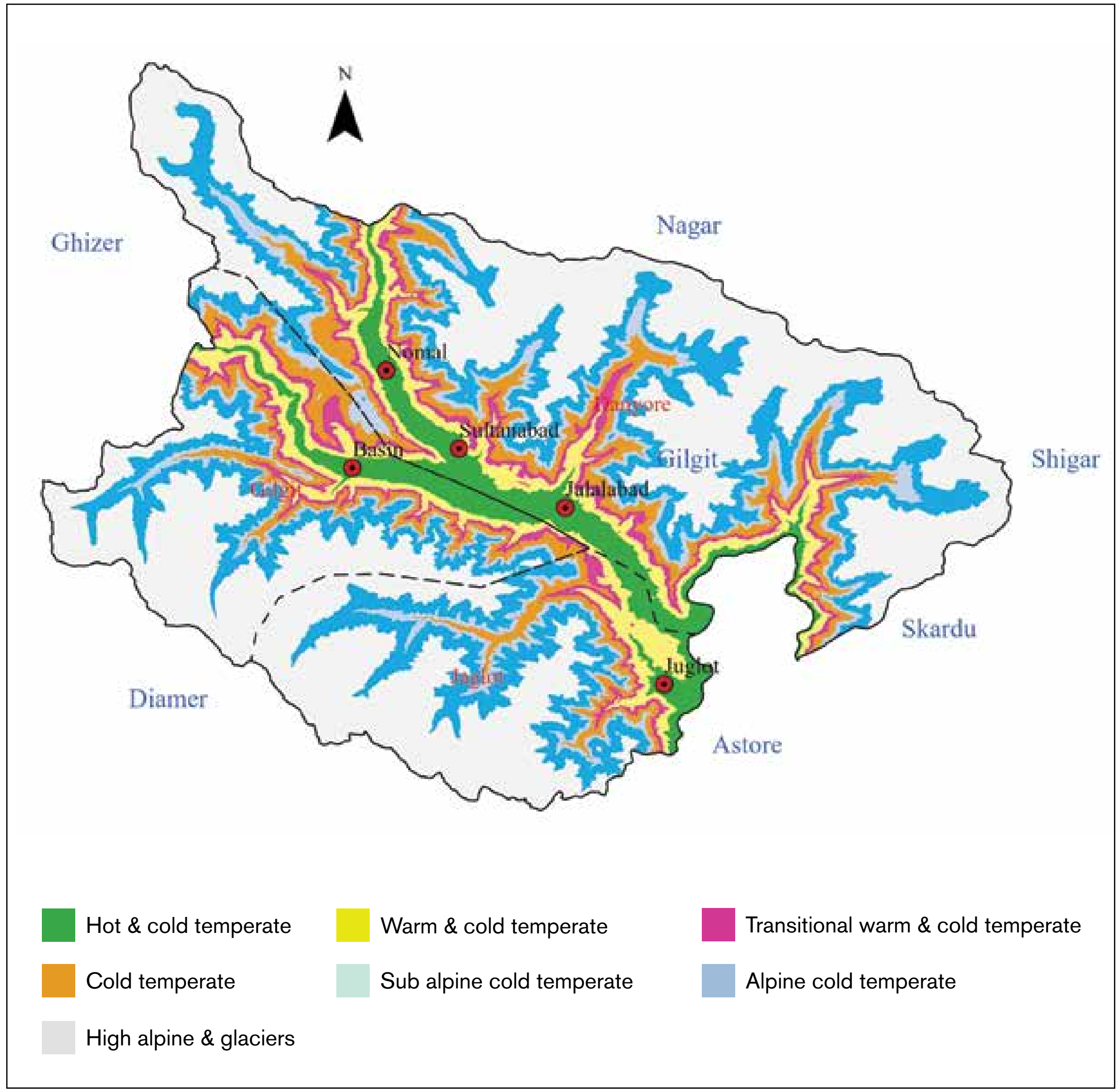
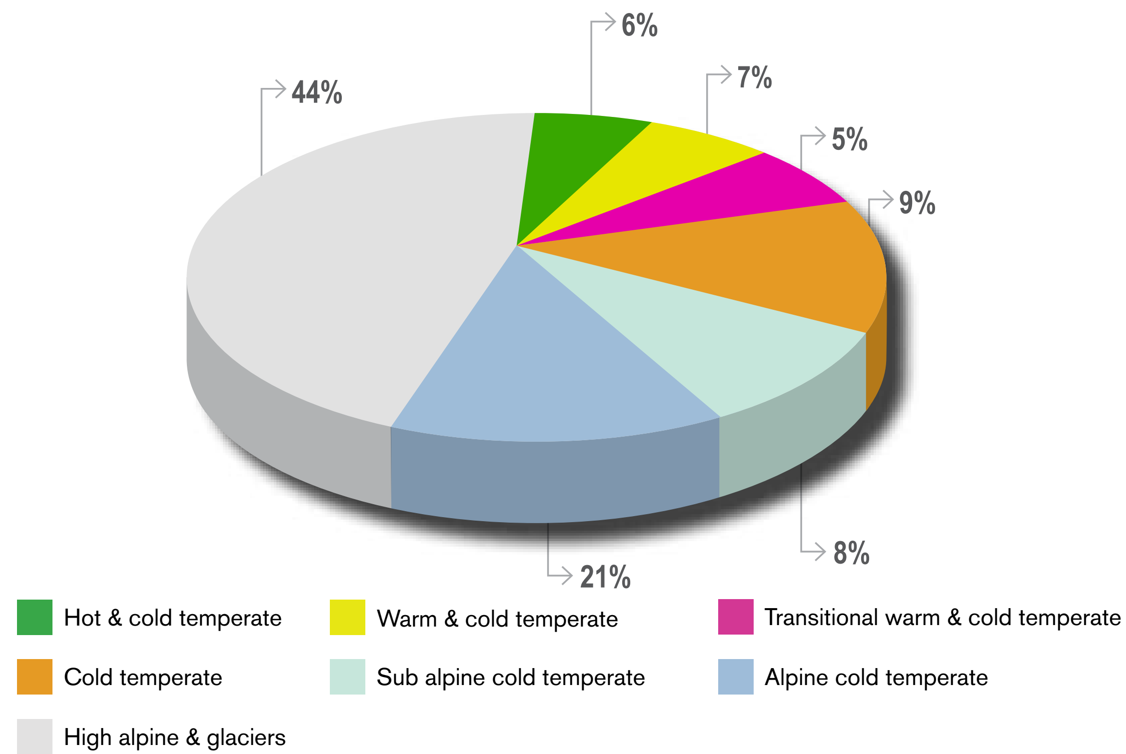


Table 7. Major locations falling in various AEZs

Agro-ecological zones	Major locations
Hot & Cold Temperate Alleviation: 4,000-5,500 feet (1,220-1,700 m) Avg. Temp.: 4.5°C Avg. Prec.: 427 mm	Gilgit has a distinct Hot & Cold temperate zone and runs all across the district in all tehsils. Major locations are as follows: Juglot, Pari Bangla, Minawar, Danyor, Gilgit, Baseen, Oshkendas, Jalalabad, Chamogarh, Sultanabad, Jutial, Lower Haramosh, Nomal, Chilmish, Henzel, Bargo, Sherote, Shikyote
Warm & Cold Temperate Alleviation: 5,500-7,000 feet (1,720-2,150 m) Avg. Temp.: 4.4°C Avg. Prec.: 389 mm	This zone thrives along Hot and Cold zone across the district. Major locations are as follows: Sai Juglot, upper Danyor, Lower Bugrot, upper Haramosh, Chikar Kot, Dass, Damote Juglot.
Transitional Warm & Cold Temperate Alleviation: 7,000-8,000 feet (2,150-2,450 m) Avg. Temp.: 3.9°C Avg. Prec.: 419 mm	This zone also prevails in all three tehsils of the district. Major locations are: Bugrot (Datoche, Harpu, Opaei, Bilchar, Chira), lower Naltar, lower Kargah, Sabeel Juglote.
Cold Temperate Alleviation: 8,000-9,500 feet (2,450-2,900 m) Avg. Temp.: 3.2°C Avg. Prec.: 441 mm	This zone is spread over a larger area and includes the following locations: Upper Bagrot, Upper Haramosh, Naltar bala, Kargah Joot.
Sub Alpine Cold Temperate Alleviation: 9,500-10,500 feet (2,900-3,200 m) Avg. Temp.: -3.5°C Avg. Prec.: 339 mm	This zone is located on higher elevations along Cold Temperate zone. It includes higher areas, mainly pastures.
Alpine Cold Temperate Alleviation: 10,500-12,500 feet (3,200-3,800 m) Avg. Temp.: -4.0°C Avg. Prec.: 259 mm	This zone is located on a large stretch at a higher elevation along Sub Alpine Cold Temperate zone. It mainly includes pastures.
High Alpine and Glaciers Alleviation: 12,500 feet + (3,800 m +) Avg. Temp.: -7.1°C Avg. Prec.: 227 mm	3800 meters above sea level and higher. This is an area which is only used as high-altitude pastures.

Figure 3. Percentage area under various AEZs

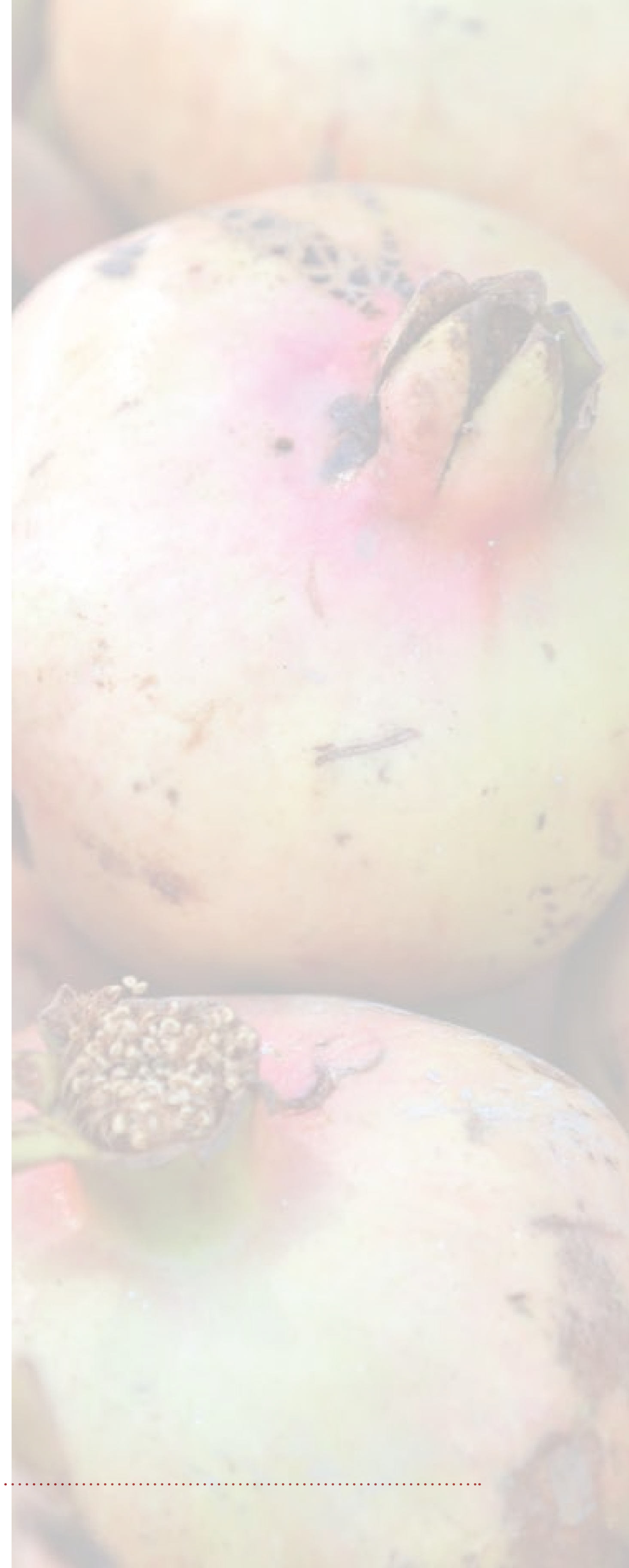


7. Agricultural potential

In an irrigated agriculture system with 4-5 months of summer, most crops may be grown in most of the zones except for the Alpine Cold Temperate zone where fruits and wheat does not ripe due to short growing season. However, some crops grow well in some zones compared to others. The recommendations, therefore, are based on what could grow well giving best yields, and not on which crops are grown at present. In addition to introducing an appropriate cropping pattern, soil fertility management and erosion control are imperative in Gilgit due to soil characteristics described earlier. The following potential has been identified in consultations with Agriculture Department and the farming community as well as assessing the climate and market potential pertaining to various AEZs of the district (**Table 8**).

Table 8. Potential of crops in various AEZs

Type	Potential crops	Remarks
Potential in Hot & Cold Temperate zone		
Cereals	Wheat (winter sowing), Maize (summer)	Wheat (winter), maize (summer)
Vegetables	Capsicum, Cucumber, Okra, tomato	Capsicum, okra, and tomato (two crops, February, and August) are high potential in this zone. These vegetables are already in high demand in the market. Tomato, cucumber, capsicum are also in demand. In addition, Chinese cabbage, green mallow (swanchal), onion, carrots are also grown for market purpose and supplied to local markets. Potato is also cultivated in this zone as an economic crop. Cucumber, tomato, bottle gourd and other suitable vegetables are recommended to be cultivated as tunnel crops due to high yields and economic profitability.
Fruit	Cherry, persimmon, and pomegranate	Top priority fruits in this zone are cherry (Nomal to Jalalabad), pomegranate (Haramosh) and persimmon due to their commercial value. In the recent years, lemon and fig are also emerging as potential crops due to increasing demand in local as well as national market.
Fodder	Clover, berseem Alfalfa, rye grass	Both berseem and alfalfa are cultivated separately or intercropped in orchards.
Potential in Warm & Cold Temperate zone		
Cereals	Wheat (winter), Maize	Among cereals, wheat in winter and maize as a second cereal crop are priority.
Vegetables	Capsicum, peas, tomato	Capsicum, followed by peas are in high demand in the market. Peas (sown in February / March) are harvested in May /June. Early harvesting is an advantage in the market. Potato and turnip are also suitable commercial crops. Tomato is planted in May and fruits for a long period till July. Cucumber and bottle gourd are also suitable to be cultivated in vertical formation.
Fruit	Apple, Pear, Apricot	This zone shows a greater affinity for apples and pears. Apricot is cultivated in small quantity.
Fodder	Barley, Alfalfa	Barley is cultivated for subsistence including for fodder. Alfalfa is cultivated separately as well as intercropped with maize.
Potential in Transitional Warm & Cold Temperate zone		
Cereals	Wheat (winter sowing only)	Subsistence cultivation of wheat takes place in this zone in spring. Economic potential of spring wheat when compared to vegetables is very low. It is recommended to use this area as high potential for vegetables and fruit production.
Vegetables	Potato, tomato, peas	Potato is a major crop in this zone followed by turnip and peas. Cucumber and tomato are proposed in vertical farming, with cabbage intercropping (or separately in the field). Carrot is also a high potential crop in this zone.



Fruit	Apple, Apricot, pear	Apple is a top fruit in this zone beside pear. Apricot in lower Naltar is grown for drying; very little apricot is marketed as fresh fruit.
Fodder	Berseem / Alfalfa	Barley is cultivated at a subsistence level including for fodder. Alfalfa is cultivated separately as well as intercropped with maize.
Potential in Cold Temperate zone		
Cereals	Wheat	This is spring wheat sowing zone. However, since land is highly limited, it is recommended to save land for marketable vegetable crops instead of spring wheat. Barley is cultivated in this zone for fodder.
Vegetables	Peas, potato (including seed potato), turnip	Potato and peas are highly viable cash crops in this zone. This zone is also suitable for producing seed potato followed by turnip. Cucumber and tomato are proposed in vertical farming, with cabbage intercropping (or separately in the field).
Fruit	None	None, since weather is highly unpredictable in this zone.
Fodder	Barley, alfalfa	Barley is cultivated for grain and fodder. Alfalfa is cultivated separately
Potential in Sub Alpine Cold Temperate zone		
Cereals	None	No specific cultivation
Vegetables	None	
Fruit	None	
Fodder	Natural pastures and crop by-product	
Potential in Alpine Cold Temperate zone		
Cereals	None	No specific cultivation
Vegetables	None	
Fruit	None	
Fodder	Natural pastures and crop by-product	


District Hunza
HUNZA
GHIZER
NAGAR
GILGIT
SHIGAR
GHANCHE
DIAMER
ASTORE
KHARMANG
SKARDU

Hunza

Latitude 36.3167° N and Longitude 74.6500° E

1. Introduction

Hunza District is situated in the Gilgit region of Gilgit-Baltistan (GB). The district is spread over an area of 10,109 sq.km (1,010,900 ha) which is 14% of the total area of GB[1]. Hunza is bounded on the south by districts Nagar and Shigar, and on the west by district Ghizer. The district headquarter is the town of Aliabad. Administratively, the district is divided into two tehsils: Aliabad and Gojal. According to the 2017 census, the total population of Hunza was 50,000 with 6,494 households at an average household size of 7.7[2] in 46[3] villages. With a growth rate of 0.36[4], the estimated population of the district is 50,907 persons in 2022. This is the lowest population growth recorded in GB. The overall literacy rate is 71% - male 80% and female 65%[5].

2. Land use statistics

According to Agriculture Department GB, the total agricultural land of the district is 6,453 ha out of which 2,114 ha is cultivated while 4,339 ha is cultivable waste[6]. The land use statistics of district Hunza are given in **Table 1**.

Table 1. Land use statistics

S.No.	Type of Land	Area (Ha)	Percentage
1.	Agricultural Land	6,453	0.6%
2.	Forest Land	5,003	0.5%
3.	Range Land & Pastures	236,673	23.4%
4.	Rivers/Lakes	32,480	3.2%
5.	Built up Area	3,841	0.4%
6.	Snow/Glaciers	313,896	31.1%
7.	Rocks	412,555	40.8%
	Total	**1,010,901**	**100%**

Source: Calculated using GIS tools based on district shape files provided by GB Agriculture department 2022

3. Current features of agriculture

The cropping pattern in Hunza is influenced by the elevation which ranges from 1860 meters (m) to above 3050 m. From 1860 m, transitional double cropping system is practiced while above 2438 m, single cropping pattern is followed. The major cereal crops of the districts are wheat, barley, maize, and buckwheat. The vegetables grown are potato, tomato, peas, cabbage, cucumber, carrot, radish, and beans. The main fruits include apricot, apple, cherry, grapes, pear, peaches, mulberry, walnut, and almond. To feed the farm animals, farmers also grow lucerne and clover as fodder crops. It is important to note that farmers practice a mix cropping pattern as a source of subsistence over centuries. Therefore, the land is used for growing multiple crops in the same season. A typical cropping pattern followed in the district is given in **Table 2.**

Table 2. Current cropping pattern

Altitude (m) and major locations (examples)	Cropping Pattern
Altitude: 1859 to below 2591 **Cropping season:** Feb–Oct Double cropping **Major location:** Main villages of lower and central Hunza	• Wheat followed by maize or vegetables and fodder – OR • Wheat followed by buckwheat, and vegetables and fodder • Potato followed by vegetables and fodder – OR • Fruits are grown extensively • Fodder is grown as irrigated perineal crop on limited scale
Altitude: 2591 to below 2743 **Cropping season:** Mar–Oct Single cropping **Major locations:** Shishkat, Gulmit, Passu, Khyber, Morkhon, Sost	• Potato, and vegetables and fodder – OR • Wheat, and vegetables and fodder – OR • Barley vegetables and fodder OR • Maize, and vegetables and fodder • Fruits are grown extensively (no grapes and pomegranate) • Fodder is grown as irrigated perineal crop on limited scale
Altitude: Above 2743 m (9000 ft) **Cropping season:** Late Apr–September Single cropping **Major locations:** Chipurson, Misgar, Shimshal	• Potato – OR • Wheat – OR • Barley – OR • Vegetables (Peas, faba beans, turnips, carrot) • Fruits are grown in limited quantities in relatively lower altitudes and no fruits on high altitudes • Fodder is grown as irrigated perineal crop on limited scale

Source: Primary data from district consultation workshops and interviews June 2022

[1] GB at a glance 2020. Government of Gilgit Baltistan
[2] Ibid
[3] Agriculture Statistics Report 2014. Gilgit Baltistan
[4] https://www.citypopulation.de/en/pakistan/cities/gilgitbaltistan
[5] GB at a Glance 2020. Government of Gilgit Baltistan
[6] Agriculture Census 2020, department of Agriculture Gilgit Baltistan

4. Soil characteristics

Hunza is the only district in GB with equal representation of Lithosols and Gleysols. Most of the agriculture takes place on Lithomorphic soils. This is also evident from the Agro-ecological zonation map which shows that all the zones prevail on lithomorphic soils and Gley soils prevail at too high elevations for agriculture, or these constitute marshy grounds and lakes. Lithomorphic soils are thin (less than 30cm deep) with slowly weathering coarse textured parent material, highly prone to land degradation and erosion. Sustainable crop production is only possible with good erosion control measures. These soils are surrounded by Gley soils prevailing along borders with other districts including Ghizer, Nagar and Shigar. Gley soils are found on higher altitudes with pastures on elevations 3500 m and above. Gley soils at higher elevation have glacial reserves.

Sandy loam is a prominent soil texture followed by silty clay loam and silty loam. Organic matter is adequate in lithosol areas with neutral to slightly alkaline pH ideal for vegetable and fruit production. **Table 3** summarises soil characteristics for Hunza.

Table 3. Summary of soil characteristics

Parent material	Organic Matter (%)	Fertility			Soil texture			pH
		NO3-N (mg kg^{-1})	P (mg kg^{-1})	K (mg kg^{-1})				
Lithosols 50% Gleysols 50%	Adequate	Low	Low	Marginal to Adequate	Silty clay loam 25%	Silt loam 10%	Silt loam 20%	Slightly alkaline

5. Climate trends

The average day time temperature in Hunza has increased from 4.4°C to 5°C since 1991 with an increase of 0.6°C in thirty years. A major increase is noted in the spring season.

The average night temperature has increased from to -7.2°C to -5.8°C since 1991, which is a rise of 1.4°C in thirty years. The nights are becoming warmer in all the months at a faster rate than the days. The spring and autumn are becoming warmer. Due to warmer springs and autumn, the crop growing season is expanding and provides the opportunity to farmers to convert some of the areas into double cropping zones. In spring season slightly more water will be available due to early onset of snowmelt. If managed properly, this water can be channelled for irrigation to bring new areas under irrigation. There was a slight increase in precipitation in Hunza between 1960 and 1990, which declined in the next 30 years.

The following sub sections provide details on day and night temperatures (**Tables 4 and 5**), and precipitation (**Table 6**). The analysis in these sections is based on average conditions. There may be year to year variations (e.g., cold wave during spring, or wetter than average or drier than average). This climate variability is not accounted for in ascertaining climate change trend.

5.1 Analysis of maximum temperature

- Mean monthly day time temperature during winter months is overall increasing since 1960, especially January and February. The December temperatures show a slightly declining trend since 1991.
- Day temperatures in spring season are increasing fastest among all seasons. Highest increase is noted in the month of March by 2.3°C since 1991, which is quite significant.
- Day temperatures in summers have increased since 1991 to varying degrees with maximum increase in July.
- Day temperatures in autumn are increasing in October but decreasing in November. Overall, autumn has also become warmer since 1960.

Table 4. Trend analysis of mean monthly maximum temperature (°C)

	1960-2020			1960-1990			1991-2020		
Months	Change from - to	Change in temperature	Trend	Change from - to	Change in temperature	Trend	Change from - to	Change in temperature	Trend
Dec	-6.4 to -6	0.4	↑	-6.7 to -5.9	0.8	↑	-5.8 to -6.4	-0.6	↓
Jan	-9.3 to -8.9	0.4	↑	-9.5 to -8.6	1.1	↑	-9.6 to -8.6	1	↑
Feb	-8.1 to -6.6	1.5	↑	-7.9 to -7.7	0.2	↑	-7.1 to -6.7	0.4	↑
Mar	-2.4 to -0.8	1.6	↑	-1.5 to -2.7	-2.2	↓	-2.3 to 0	2.3	↑
Apr	3.8 to 5.2	1.4	↑	3.8 to 4.8	1	↑	4 to 5.7	1.7	↑
May	7.8 to 8.6	1.8	↑	7.6 to 8.4	0.8	↑	7.8 to 8.8	1	↑
Jun	13.2 to 12.7	-0.5	↓	13.4 to 12.8	-0.6	↓	12.5 to 13	0.5	↑
Jul	16.9 to 16.9	0	↔	16.9 to 17	0.1	↑	16.5 to 17.2	0.7	↑
Aug	16.7 to 16.5	-0.2	↓	16.8 to 16.9	0.1	↑	16.4 to 16.5	0.1	↑
Sep	13.1 to 13.4	0.3	↑	12.7 to 13.7	1	↑	13.1 to 13.4	0.3	↑
Oct	6.5 to 7.1	0.6	↑	6.7 to 6.8	0.1	↑	6.5 to 7.3	0.8	↑
Nov	-0.7 to 0.5	1.2	↑	-1.2 to 0.2	1.4	↑	0.7 to -0.1	-0.8	↓

5.2 Analysis of minimum temperature

- Mean monthly night temperatures during winter months are overall increasing in the last thirty years. In the period from 1960 this increase is between 1.5°C and 1.8°C. The night temperatures for December are showing a declining trend since 1991, even though it had increased from 1960 to 1990.
- The increase in night temperatures is higher when compared to day temperatures in the spring months with maximum increase in the months of March and April.

- Summer nights are also becoming warmer as the night temperatures are increasing with a maximum change observed in the months of August and September.
- Warming trend is also observed in autumn with the highest increase in October. Autumn is starting late and becoming milder.

Table 5. Trend analysis of mean monthly minimum temperature (°C)

	1960-2020			1960-1990			1991-2020		
Months	Change from - to	Change in temperature	Trend	Change from - to	Change in temperature	Trend	Change from - to	Change in temperature	Trend
Dec	-16.4 to -14.9	1.5	↑	-17.1 to -15	2.1	↑	-14.9 to -15.6	-0.7	↓
Jan	-19.5 to-17.7	1.8	↑	-19.9 to -18	1.9	↑	-18.7 to -17.8	0.9	↑
Feb	-18 to -16.2	1.8	↑	-17.5 to -17.6	-0.1	↓	-16.9 to -16.1	0.8	↑
Mar	-12.6 to -10.2	2.4	↑	-12 to -11.8	0.2	↑	-11.8 to -9.6	2.2	↑
Apr	-7.4 to -5.3	2.1	↑	-7.1 to -6.4	0.7	↑	-7.1 to -4.8	2.3	↑
May	-4.6 to -2.5	2.1	↑	-4.5 to -3.5	1	↑	-3.9 to -2.2	1.7	↑
Jun	0.2 to 1.1	0.9	↑	0.5 to 0.3	-0.2	↓	0.4 to 1.4	1	↑
Jul	3.4 to 4.6	1.2	↑	3.8 to 3.6	-0.2	↓	3.4 to 5.1	1.7	↑
Aug	3 to 4.5	1.5	↑	3.4 to 3.5	0.1	↑	3 to 5.1	2.1	↑
Sep	-1.5 to 0.2	1.7	↑	-1 to -1.2	-0.2	↓	-1.3 to 0.7	2	↑
Oct	-7.1 to -5.2	1.9	↑	-6.6 to -6.5	0.1	↑	-6.9 to -4.5	2.4	↑
Nov	-12.4 to -11.1	1.3	↑	-12.5 to -11.5	1	↑	-11.8 to -11	0.8	↑

5.3 Analysis of precipitation

- Precipitation is increasing since 1960 in winter.
- Reduction in precipitation is observed in spring season, consistently declining since 1960.
- In summers, precipitation has increased since 1960. This increasing trend has, however, started slowing down since 1991 and is showing a negative trend.
- Overall, autumn precipitation has not shown any significant change and precipitation has remained the same.

Table 6. Trend analysis of annual and seasonal precipitation (mm)

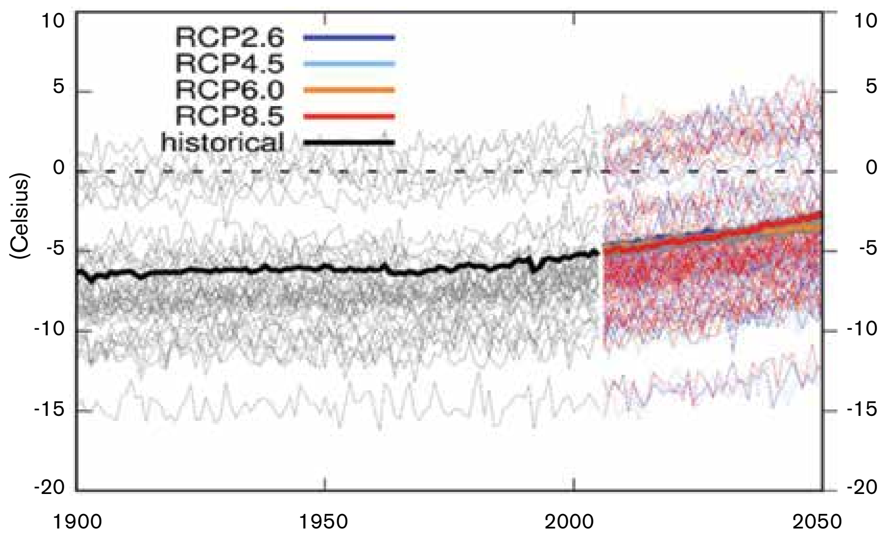
	1960-2020			1960-1990			1991-2020		
Season	Change from – to	Change in precipitation	Trend	Change from - to	Change in precipitation	Trend	Change from - to	Change in precipitation	Trend
Annual	261 to 266	5	↑	259 to 262.5	3.5	↑	271.5 to 259.5	-12	↓
Winter	73 to 87	14	↑	71 to 82	11	↑	82 to 85	3	↑
Spring	124 to 108	-16	↓	132 to 104	-28	↓	125 to 105	-20	↓
Summers	33 to 44	11	↑	29 to 41	12	↑	44 to 40	-4	↓
Autumn	31 to 26	-5	↓	27 to 36	9	↑	20 to 30	10	↑

5.4 Climate scenarios

Figure 1 gives near surface temperature projections till 2050 based on different GHG emissions scenarios and how these emissions will affect the temperature in Hunza. Taking the historical trend from 1900, time series shown in **Figure 1** projects that under different GHG emissions reduction scenarios the mean near surface temperature of Hunza will be between -3.5°C and -2.5°C in 2050 which was around -6°C in 1900. This is an increase of 2.5°C to 3.5°C, rather significant since 1900 to 2050.

To adapt to these changes, farmers will have to rely more on irrigation and not on rains. The early snowmelt in spring due to increased temperature may be advantageous for agriculture but this can also trigger flash floods during spring. In spring and summer, agricultural practices will be dependent on irrigation since rains are declining. During late summer and autumn, irrigation water will be short due to early melting of snow. Increased temperature also does not allow snow to stay long and build glacial reserves which are more important for sustainable water cycle.

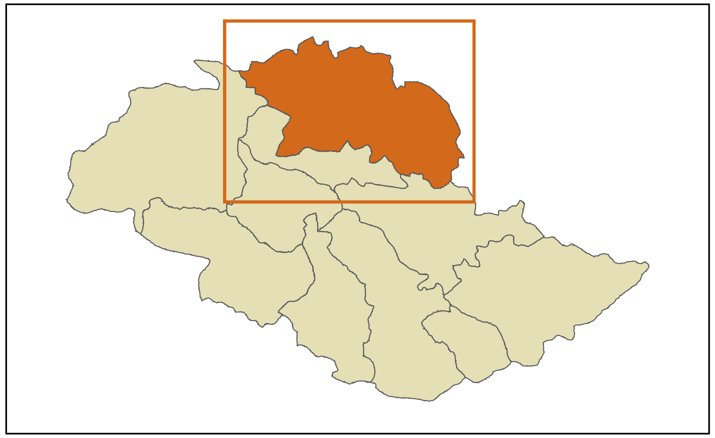
Figure 1. Temperature projection till 2050



Source: IPCC Assessment Report 5 – 2014

6. Agro-ecological zones

Hunza has 6 Agro-ecological zones (AEZs) with rich agricultural diversity. **Figure 2** presents an AEZs map which is supported by **Table 7** with major locations falling in various zones. **Figure 3** presents percentage of each zone prevalent in the district.



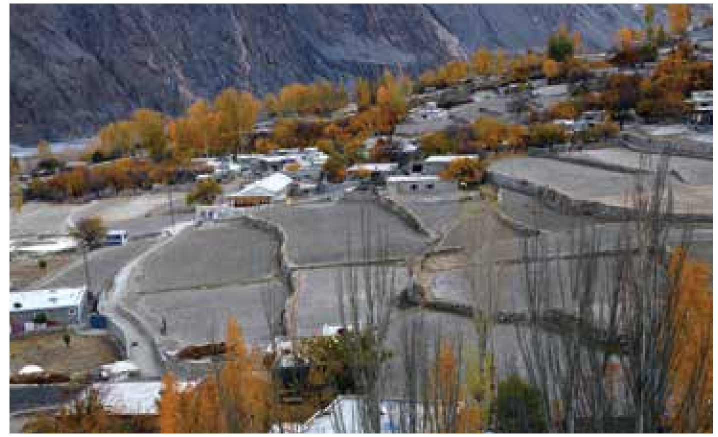


Figure 2. Agroecological zones of Hunza District

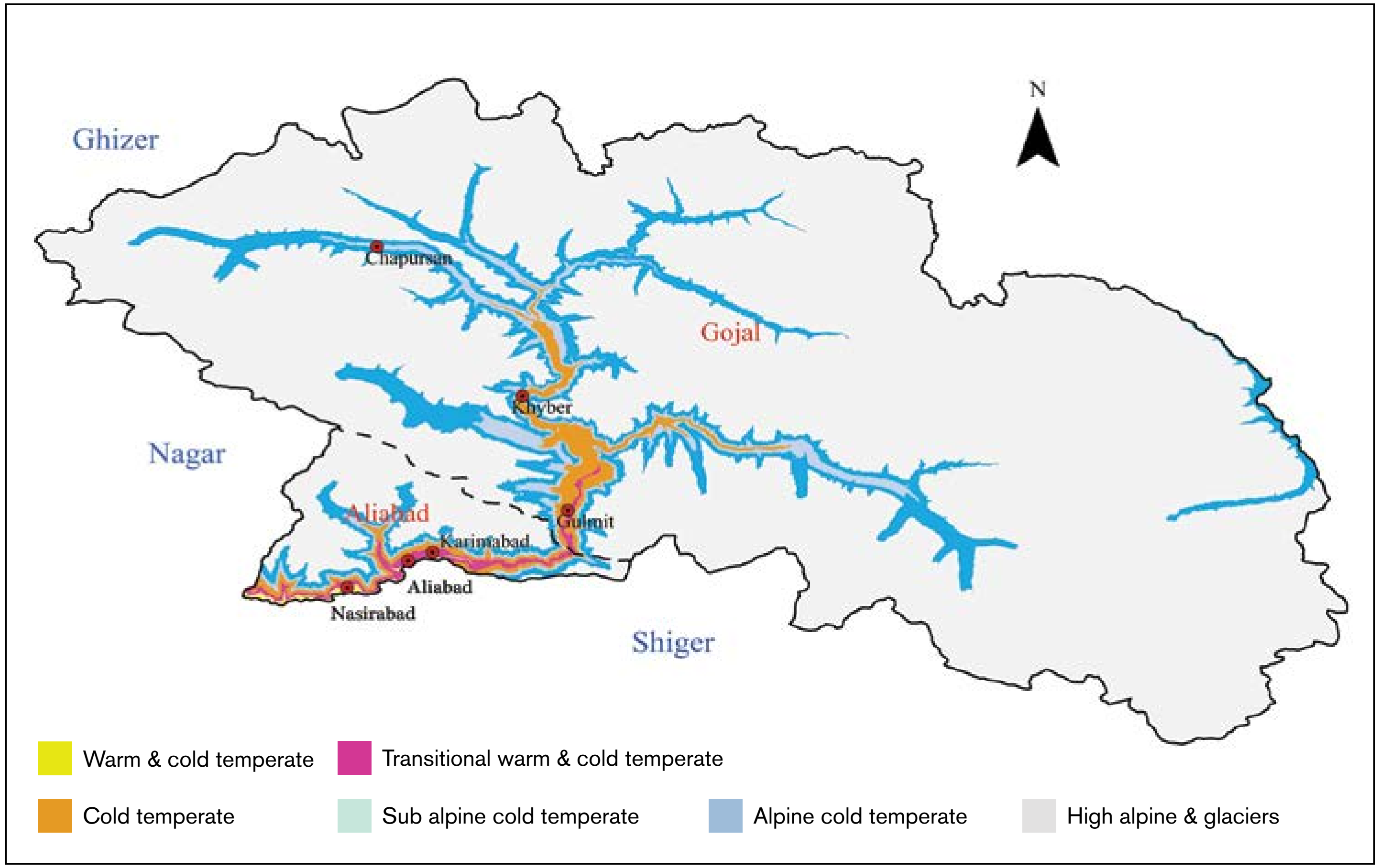
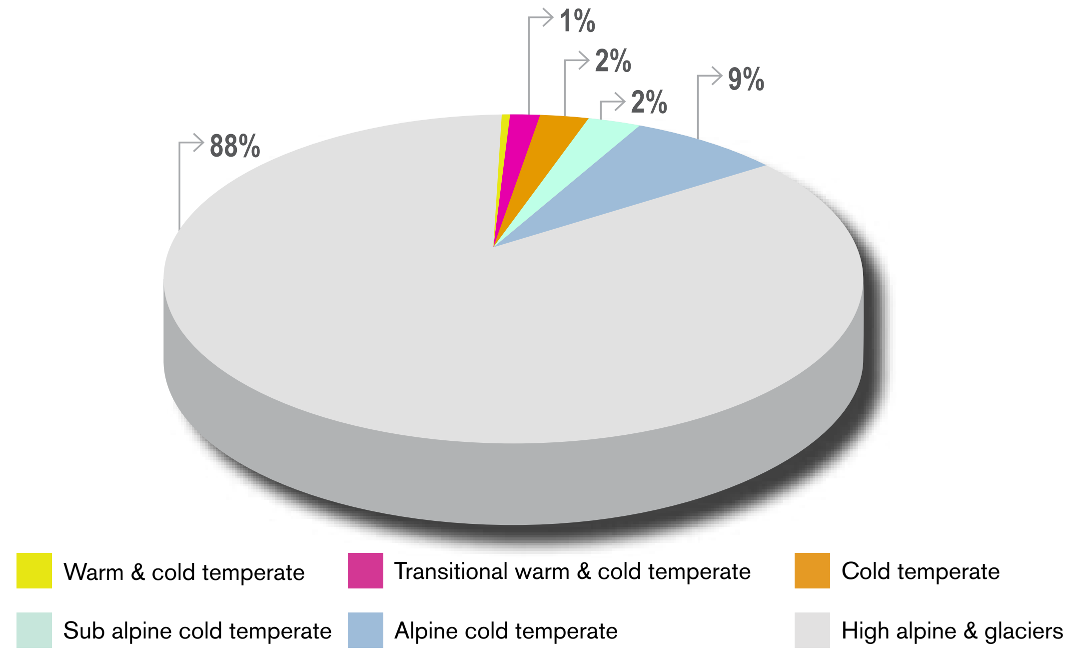


Table 7. Major locations falling in various AEZs

	Agro-ecological zones	Major locations
	Warm & Cold Temperate Alleviation: 5,500-7,000 feet (1,720-2,150 m) Avg. Temp.: 4.4°C Avg. Prec.: 389 mm	There is a very small strip of this zone adjoining lower Nagar. Major locations include boundary of lower Hunza i.e., Shinaki (Nasirabad, Hussainabad, Khanabad).
	Transitional Warm & Cold Temperate Alleviation: 7,000-8,000 feet (2,150-2,450 m) Avg. Temp.: 3.9°C Avg. Prec.: 419 mm	This is also a small area located in central Hunza. Locations include Murtazabad, Aliabad, Hassanabad, Hyderabad, Karimabad, Ganish, and Altit.
	Cold Temperate Alleviation: 8,000-9,500 feet (2,450-2,900 m) Avg. Temp.: 3.2°C Avg. Prec.: 441 mm	This zone is in the main valley of upper Hunza and some high-altitude villages of central Hunza including Altit, Duikar, Ahmadabad, Khyber, Gulmit, Shishkat, Passu, Sost, and Khudabad.
	Sub Alpine Cold Temperate Alleviation: 9,500-10,500 feet (2,900-3,200 m) Avg. Temp.: -3.5°C Avg. Prec.: 339 mm	This zone is stretched at higher elevations of the earlier zones including Shimshal, Chipursan and Misgar
	Alpine Cold Temperate Alleviation: 10,500-12,500 feet (3,200-3,800 m) Avg. Temp.: -4.0 °C Avg. Prec.: 259 mm	This zone is stretched in remote parts of district beyond settlements at higher altitudes. This is the largest zone. Areas include upper Shimshal, upper Chipursan (Baba Ghundi), Upper Misgar
	High Alpine and Glaciers Alleviation: 12,500 feet + (3,800 m +) Avg. Temp.: -7.1 °C Avg. Prec.: 227 mm	Areas above 3800 meters. This is an area which is only used as high-altitude pastures and not for crops.

Figure 3. Percentage area under various AEZs



7. Agricultural potential

In an irrigated agriculture system, most crops may be grown in most of the zones except for the Alpine Cold Temperate zone where fruits and wheat does not ripe due to short growing season. However, some crops grow well in some zones compared to others. The recommendations therefore are based on what could grow well giving best yields, and not on which crops are grown at present. Upper Hunza has high potential for vegetable seed and seed potato production due to isolation. In addition to introducing an appropriate cropping pattern, soil fertility management and erosion control are imperative in Hunza due to soil characteristics described earlier. The following potential has been identified in consultations with the Agriculture Department and farming community as well as assessing the climate and market potential pertaining to various AEZs of the district (**Table 8**).

Table 8. Potential of crops in various AEZs

Type	Potential crops	Remarks
Potential in Warm & Cold Temperate zone		
Cereals	Wheat (winter sowing), Maize, Quinoa, and buckwheat may be high potential	Wheat sown in winter and maize as a second cereal crop are priority. Quinoa has been proposed as a high potential superfood crop. Buckwheat being an indigenous crop can again emerge as future potential crop. Now this crop is at diminishing stage due to changes in cropping system.
Vegetables	Potato, cucumber, peas, tomato	Over the last three decades Potato has emerged as cash crop due to high demand in the market. Peas sown in February / March and harvested in May /June can also become a lucrative crop. Tomato and cucumber as tunnel crops cultivated in March-April and harvested in August-September are in demand in the local markets.
Fruit	Cherry, apple, apricot	This zone has a great potential for cherry which being is cultivated on large scale during the last 20-30 years. Apple and apricot also grow well in this zone. Fresh Apples and dried apricots are currently marketed while marketing of fresh apricots has a great potential in the future.
Fodder	Barley, Alfalfa	Alfalfa is mostly intercropped for fodder in the orchards. Barley is cultivated as a second crop after potato or wheat as a fodder and forage crop.
Potential in Transitional Warm & Cold Temperate zone		
Cereals	Wheat (winter sowing only)	Wheat is currently cultivated for subsistence. Only winter wheat can be economical. Its economic returns compared to fruits and vegetables is significantly low. It is suggested to transform this area into fruits and vegetable basket.
Vegetables	Potato, capsicum, peas, cabbage	Potato is a major crop in this zone followed by tomato, cabbage, and leafy vegetables. Cucumber and tomato are proposed in vertical farming. Carrot is also a high potential crop in this zone.
Fruit	Apricot, Apple, Cherry	Apple, cherry, and apricot have a great potential in the zone both for local consumption and marketing.
Fodder	Barley, Maize, Alfalfa	Barley is cultivated at a subsistence level including for fodder. Alfalfa is cultivated separately as well as intercropped with orchards.
Potential in Cold Temperate zone		
Cereals	Wheat	Wheat is mainly sown in spring in this zone as food security crop. However other cash crops including potato can be more economical compared to wheat. To supplement cash income of farm families, vegetables can be introduced. Barley is cultivated in this zone as a short duration crop both for grain and fodder.
Vegetables	Potato, peas, carrot, turnip	The area is famous for seed and table potato production due to high attitude valleys in this zone. This crop is sown on commercial scale having an established value chain. Besides potato, peas, carrot, and turnip are highly viable cash crops. Another potential cash crop may be Faba beans or black bean cultivated in periphery or intercropped with orchards. Cucumber and tomato are proposed as tunnel crops.
Fruit	Apricot, apple	Premium quality fresh and dried apricots are produced in this zone. This zone is famous for its dried apricots which is mainly exported. Other high potential fruit crop is apple and cherry. Due to increased flow of tourist fruits and vegetables have a high potential.

Fodder	Barley, alfalfa	Barley is grown both for grain and fodder. Alfalfa is cultivated along peripheries, in the fields, and intercropping with orchards
Potential in Sub Alpine Cold Temperate zone		
Cereals	wheat	Economic potential of wheat when compared to vegetables is very low and not recommended. It is recommended to use this area as high potential for short duration vegetable crops.
Vegetables and pulses	Potato, peas, lentil, sesame	Beside peas, table potato and seed potato (except in Shimshal) are both high potential crops in this zone in Hunza. Besides, lentil, local peas, linseed, and leafy vegetables are viable crops in this zone. A high potential crop may be black bean or Faba beans cultivated along periphery or intercropped with orchards.
Fruit	None	
Fodder	Alfalfa, barley	Mostly this zone is catered by natural pastures. Main cultivated fodder in this zone is alfalfa. In addition, short duration barley may be cultivated for fodder.
Potential in Alpine Cold Temperate zone		
Cereals	None	
Vegetables	Peas, turnips	Although there is very little cultivation in this zone. Peas and turnip along leafy vegetables are short duration crops that may be cultivated.
Fruit	None	
Fodder	Natural pastures and crop by-product	No specific cultivation

Agro-Ecological Zones

Kharmang

Latitude 34.7416° N and Longitude 76.1592° E

1. Introduction

District Kharmang is situated in Baltistan region. The district is spread over an area of 6,144 sq.km (614,400 ha) which is 8% of the total area of Gilgit-Baltistan (GB)[1]. Kharmang is bounded by Skardu to the north-west, Ghanche to the North-East, and Deosai plains in the south. The district headquarter is Tolti. Kharmang is located at an average elevation ranging from 2300 meter (m) 3200 m. The tourists' hotspots are Manthokha and Khamosh waterfalls. Administratively, Kharmang consists of a single tehsil. The population in 2017 was 50,000 with 6,410 households at an average household size of 7.8[2] in 42[3] villages. Taking a growth rate of 0.93[4], the estimated population of the district in 2022 is 52,369. The overall literacy rate is reported to be 49% - 67% for males and 37% for females[5].

2. Land use statistics

According to Agriculture Department GB, the total agricultural land of the district is 3,411 ha. Out of which 1,153 ha is cultivated while 2,258 ha is cultivable waste[6]. The land use statistics of district Kharmang are given in **Table 1**.

Table 1. Land use statistics

S.No.	Type of Land	Area (Ha)	Percentage
1.	Agricultural Land	3,411	0.6%
2.	Forest Land	2,396	0.4%
3.	Range Land & Pastures	118,475	19.3%
4.	Rivers/Lakes	18,566	3%
5.	Built up Area	10,936	1.8%
6.	Snow/Glaciers	111,288	18%
7.	Rocks	288,454	47%
8.	Unaccounted for	60,872	9.9%
	Total	**614,400**	**100%**

Source: Calculated using GIS tools based on district shape files provided by GB Agriculture department 2022

3. Current features of agriculture

The crops grown and cropping pattern in Kharmang are influenced by the elevation which ranges from about 2300 meters (m) to 3200 m. In the lower parts of the district, a major crop is followed by a short duration crop whereas in the upper parts a single crop is grows in the season. The major cereal crops of the district are barley, wheat, maize, millet, and buckwheat. The vegetables grown are potato, peas, turnip, tomato, cabbage, radish, and carrot. Major fruits include apricot, apple, mulberry, walnut, and almond. Although, elevation wise area of each crop differs from each other but overall the district falls under single cropping system. Wheat is also cultivated in smaller quantities in warmer pockets. Fodder and vegetables are also grown extensively. It is important to note that farmers grow mix crops in the same season. The typical cropping pattern followed in the district is given in **Table 2**.

Table 2. Current cropping pattern

Elevation (m) and major locations (examples)	Cropping Pattern
Altitude: 2470 to below 2685 **Cropping season:** 3rd week Mar–Sep Single cropping **Major locations:** Mehdiabad, Ghasing, Gahori, Hilal-abad lower, Kamango, Tolti, Lower Pari, Mayordo, Ghanoush, Baghicha and Tarkati lower.	• Wheat followed by fodder in some areas – OR • Barley followed by millet – OR • Barley followed by vegetables • Potato – fallow • Vegetable on small areas parallel to crops • Fodder as irrigated perennial crop • Fruits are extensively grown (apricot, apple, almond, mulberry, cherry, pear, peach, walnut, grape)
Altitude: 2685 to below 2900 **Cropping season:** April–Aug Single cropping **Major locations:** Sundo, Shamayal, Tolti Broq, Broqkhar, Hilalabad upper, Azeemabad, Tolti upper, Pari upper, Kinderik, Torghon middle, Hamzigond and Olding.	• Spring wheat - fallow – OR • Barley followed by millet – OR • Barley followed by buckwheat – OR • Potato – fallow • Vegetable on small areas parallel to crops • Fodder as irrigated perennial crop • Fruits in large quantities (apple, apricot, walnut, mulberry, almond)
Altitude: 2900 and above **Cropping season:** Middle April–Aug Single cropping **Major locations:** Dapa, Mantho, Kosoro, Harghosil, Memosh, Ganokh, Brasil, Ghavis and Bilargo	• Barley - fallow – OR • Buckwheat – fallow OR • Potato – fallow • Vegetable on small areas parallel to crops • Fodder as irrigated perennial crops • Fruits in small quantities (apricot, walnut, almond)

Source: Primary data from district workshops and interviews

[1]GB at a glance 2020. Government of Gilgit Baltistan
[2]Ibid
[3]Agriculture Statistics Report 2014. Gilgit Baltistan
[4]https://www.citypopulation.de/en/pakistan/cities/gilgitbaltistan
[5]GB at a Glance 2020. Government of Gilgit Baltistan
[6]Agriculture Census 2020, department of Agriculture Gilgit Baltistan

4. Soil characteristics

Kharmang has three soil types of which Lithosols are dominant followed by Eutric Cambisols and two nominal patches of Gleysols. Lithomorphic soils are thin (less than 30cm depth) with slowly weathering coarse textured parent material, highly prone to land degradation and erosion. Sustainable crop production is a challenge on these soils since these soils need a lot of care and conservation measures. More attention is required for its conservation; if this shallow soil is lost, it will be a long weathering process before new soil is formed. These soils prevail along borders with Skardu and Ghanche. There is a significant strip of Eutric Cambisol in the middle of the district and this is also where most of the agriculture is practiced. Cambisols are among the most productive soils on earth and for Kharmang it is an opportunity to have these soils just at the right altitudes with all four significant agro-ecological zones explained in later sections. Two small patches of Gley soils are on high altitude along Skardu's border and do not support any kind of agricultural activity.

Sandy loam is a prominent soil texture found in Kharmang followed by silty clay loam and silt loam. Organic matter is relatively marginal, and the pH is generally neutral. **Table 3** summarises soil characteristics for Kharmang.

Table 3. Summary of soil characteristics

Parent material	Organic Matter (%)	Fertility			Soil texture			pH
		NO3-N (mg kg^{-1})	P (mg kg^{-1})	K (mg kg^{-1})				
Lithosols 60% Cambisols 30% Gleysols 10%	Marginal	Low	Low	Low	Sandy loam 45%	Loam 30%	Silt loam 25%	Neutral

5. Climate trends

Average day and night temperatures are increasing in Kharmang. A larger increase is noted for spring season. An average day time temperature has increased to 7.3°C from 6.6°C since 1991. The major increase is noted in the past 30 years. The average night temperature of Kharmang has increased from -5.1°C to -3.7°C since 1991. Nights are becoming warmer. Seasonal changes are chained from spring arriving earlier than before, autumn stretching into winter months and winter arriving later than before. Autumn is becoming milder. Due to warmer springs and autumns, crop growing season is expanding providing an opportunity to the farmers to grow longer duration crops or a short duration crop after the main crop. In spring season, more water will be available due to early onset of snowmelt because of increase in temperatures. This may allow early sowing of crops but may not allow the snow to consolidate. Early snowmelt may result in flash floods during the spring season. The increase in night temperatures is more as compared to day temperatures particularly in the spring months.

Overall precipitation has increased in Kharmang; however, this increase is mainly recorded in the winters and summers against the base year of 1960. In the last three decades the trend changed and precipitation started reducing in winters, spring, and summers with a slightly increasing trend during the autumns.

Following sub sections provide details on day and night temperatures (**Tables 4 and 5**), and precipitation (**Table 6**). The analysis in these sections is based on average conditions. There may be year to year variations (e.g., cold wave during spring, or wetter than average or drier than average). This climate variability is not accounted for in ascertaining climate change trend.

5.1 Analysis of maximum temperature

- Mean monthly day time temperature during the winter months is increasing. Major change is in the months of January and February. In December temperature had increased after 1960 but declined after 1991.
- Day temperatures in spring season show highest increase compared to other season with most significant increase in March and April, i.e., an increase of 1.9°C since 1991.
- Day temperatures in summers have increased since 1991 with maximum increase in July.
- Day temperatures in autumn have increased for October and is stable in November since 1991. Overall, autumn has also become warmer since 1960.

Table 4. Trend analysis of mean monthly maximum temperature (°C)

	1960-2020			1960-1990			1991-2020		
Months	Change from - to	Change in temperature	Trend	Change from - to	Change in temperature	Trend	Change from - to	Change in temperature	Trend
Dec	-3 to -2.4	0.6	↑	-3.1 to -2.8	0.3	↑	-2.3 to -2.7	-0.4	↓
Jan	-6 to -6.1	-0.1	↓	-6.1 to -5.7	0.4	↑	-6.3 to -5.7	0.6	↑
Feb	-5.1 to -3.8	1.3	↑	-4.8 to -4.9	-0.1	↓	-4.2 to -3.8	0.4	↑
Mar	0.6 to 2	1.4	↑	1.5 to 0.3	-1.2	↓	0.8 to 2.7	1.9	↑
Apr	6 to 7.6	1.6	↑	6.2 to 6.8	0.6	↑	6.2 to 8.1	1.9	↑
May	9.4 to 10.6	1.2	↑	9.5 to 10	0.5	↑	9.7 to 10.7	1	↑
Jun	14.6 to 13.9	-0.7	↓	15 to 13.9	-1.1	↓	14.1 to 14.1	0	↔
Jul	18.3 to 18.1	-0.2	↓	18.5 to 18.1	-0.4	↓	18 to 18.4	0.4	↑
Aug	17.7 to 17.4	-0.3	↓	17.7 to 17.6	-0.1	↓	17.4 to 17.5	0.1	↑
Sep	14.9 to 15	0.1	↑	14.9 to 15	0.1	↑	14.8 to 15.1	0.3	↑
Oct	8.9 to 9.5	0.6	↑	9.4 to 8.7	-0.7	↓	8.7 to 10	1.3	↑
Nov	2.4 to 3.4	1	↑	2.4 to 2.8	0.4	↑	3.2 to 3.2	0	↔

5.2 Analysis of minimum temperature

- Mean monthly night temperatures during the winter months have increased in the last

30 years. In the period from 1960 this increase is between 1.3°C and 1.7°C. The night temperatures for December have decreased since 1991, which were increasing in the period 1960 to 1990.

- Since 1960, the nights have become warmer in spring by more than 2°C. The increase is higher in the last 30 years. The increase in night temperatures is higher as compared to day temperatures in the spring months.
- Summer nights are also becoming warmer as the night temperatures are increasing more than the daytime temperatures with a maximum change observed in August and September.
- Warming trend is also observed in autumn with the highest increase in October. Autumn is starting late and becoming milder.

Table 5. Trend analysis of mean monthly minimum temperature (°C)

	1960-2020			1960-1990			1991-2020		
Months	Change from - to	Change in temperature	Trend	Change from - to	Change in temperature	Trend	Change from - to	Change in temperature	Trend
Dec	-13.8 to -12.1	1.7	↑	-14.1 to -12.8	1.3	↑	-12.4 to -12.5	-0.1	↓
Jan	-16.4 to -15.1	1.3	↑	-16.6 to -15.4	1.2	↑	-15.7 to -15.2	0.5	↑
Feb	-15.3 to -13.8	1.5	↑	-14.9 to -15.2	-0.3	↓	-14.3 to -13.4	0.9	↑
Mar	-10.3 to -8.3	2	↑	-9.7 to -10	-0.3	↓	-9.7 to -7.9	1.8	↑
Apr	-5.8 to -3.5	2.3	↑	-5.3 to -5	0.3	↑	-5.3 to -2.9	2.4	↑
May	-3.6 to -1.2	2.4	↑	-3.4 to -2.6	0.8	↑	-2.6 to -0.9	1.7	↑
Jun	1.8 to 2.9	1.1	↑	2.4 to 1.8	-0.6	↓	2 to 3.3	1.3	↑
Jul	5.2 to 6.2	1	↑	5.6 to 5.1	-0.5	↓	5.4 to 6.6	1.2	↑
Aug	5 to 6	1	↑	5.4 to 5	-0.4	↓	4.9 to 6.6	1.7	↑
Sep	0.7 to 2.1	1.4	↑	1.2 to 0.8	-0.4	↓	1 to 2.6	1.6	↑
Oct	-5 to -3.1	1.9	↑	-4.3 to -4.8	-0.5	↓	-4.8 to -2.3	2.5	↑
Nov	-10.3 to -8.6	1.7	↑	-10.2 to -9.6	0.6	↑	-9.6 to -8.4	1.2	↑

5.3 Analysis of precipitation

- Overall precipitation had increased since 1960 but has decreased during the last 30 years.
- Precipitation has slightly decreased in the spring season.
- Precipitation in summers had increased since 1960 which has decreased since 1991.
- Precipitation in autumn had slightly reduced since 1960 but has increased during the last 30 years.

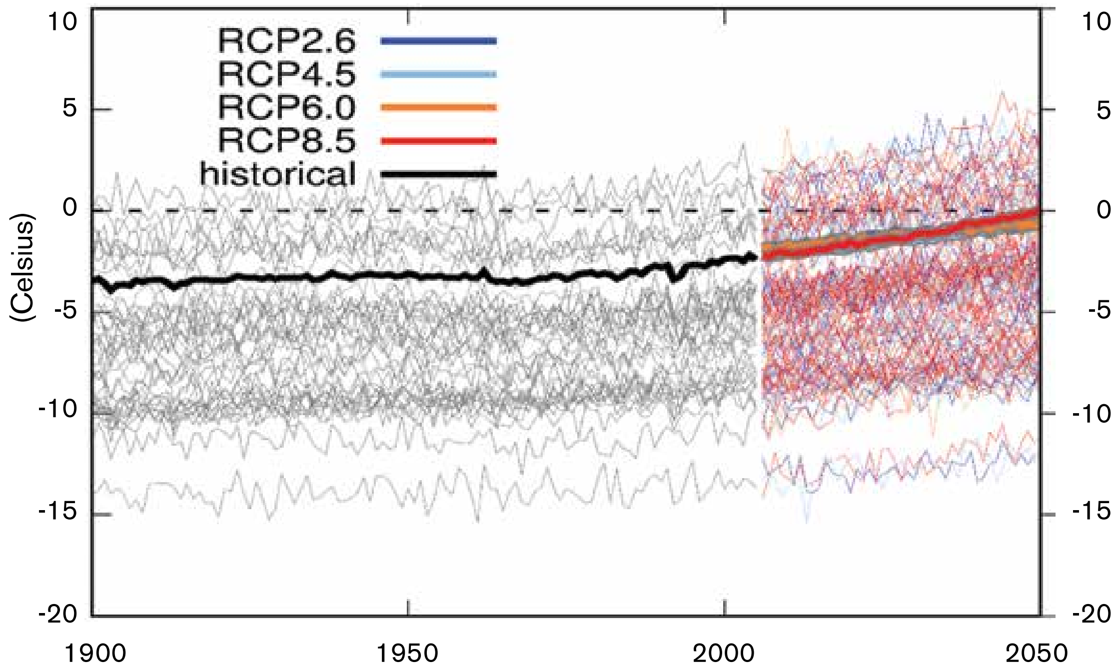
Table 6. Trend analysis of annual and seasonal precipitation (mm)

	1960-2020			1960-1990			1991-2020		
Season	Change from - to	Change in precipitation	Trend	Change from - to	Change in precipitation	Trend	Change from - to	Change in precipitation	Trend
Annual	341 to 387	46	↑	316 to 395	79	↑	371 to 374	3	↑
Winter	83 to 99	16	↑	77 to 98	21	↑	95 to 93	-2	↓
Spring	127 to 125	-2	↓	122 to 133	11	↑	124 to 123	-1	↓
Summer	104 to 138	34	↑	94 to 130	36	↑	130 to 129	-1	↓
Autumn	29 to 27	-2	↓	23 to 35	12	↑	22 to 29	7	↑

5.4 Climate scenarios

Data in **Figure 1** is based on near surface temperature and presents projections till 2050 based on different CO_2 emissions scenarios and how these emissions will affect the temperature in Kharmang. Taking the historical trend from 1900 the given time series projects that under different CO_2 emissions reduction scenarios the mean near surface temperature of Kharmang will be between 0°C and -1°C which was around -3.5°C in 1900. This is a significant change with 2.5°C increase and may have significant implication for glacial reserves.

Figure 1. Temperature projection till 2050



Source: IPCC Assessment Report 5 – 2014

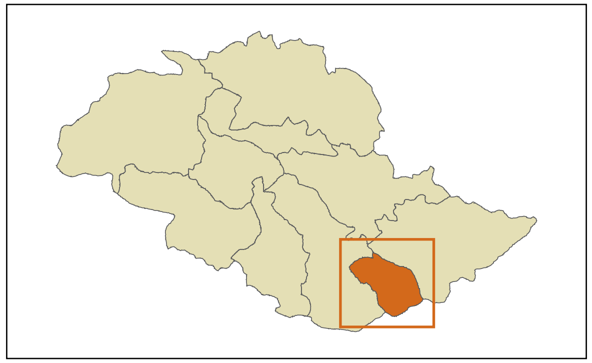
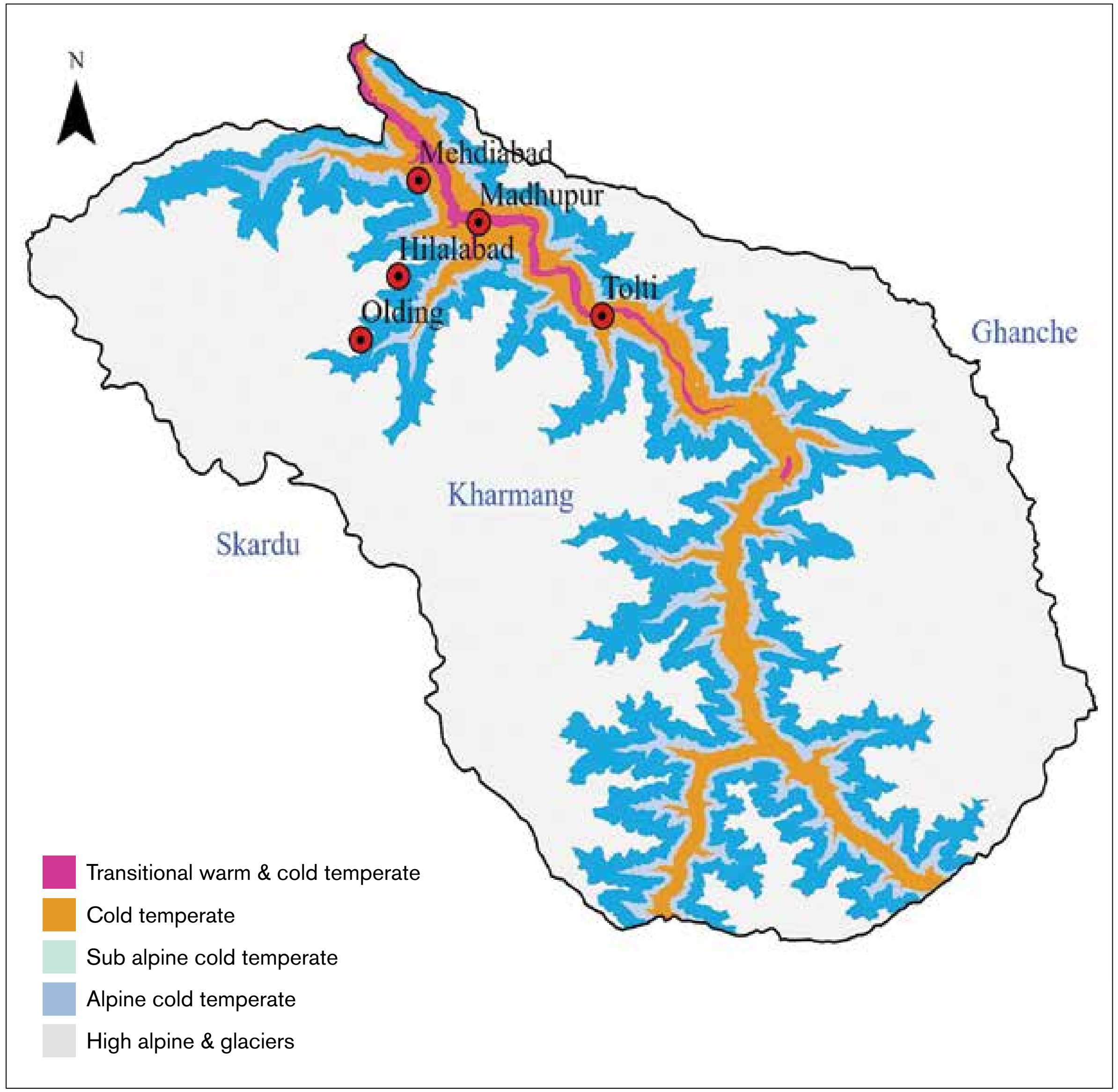


Figure 2. Agroecological zones of Kharmang District



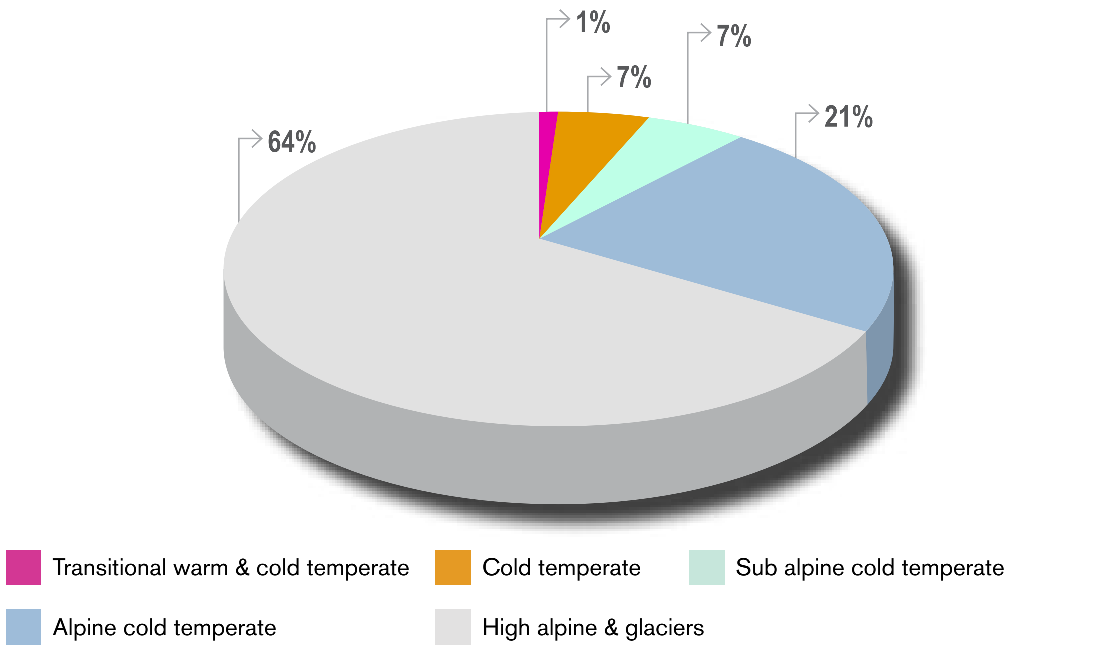
6. Agro-ecological zones

Kharmang has five Agro-ecological zones (AEZs). Cold temperate and sub alpine cold temperate zones prevail across Kharmang in parallel on different elevations. Alpine cold temperate zone is the largest in Kharmang among zones where agricultural activity is possible. This is the zone which barely supports a single crop during limited summer. **Figure 2** gives AEZs map of Kharmang while **Table 7** provides some of the major locations of the district falling in each zone. **Figure 3** provides percentage area of the district falling in different zones.

Table 7. Major locations falling in various AEZs

Agro-ecological zones	Major locations
Transitional Warm & Cold Temperate Alleviation: 7,000-8,000 feet (2,150-2,450 m) Avg. Temp.: 3.9°C Avg. Prec.: 419 mm	This zone is mainly located in the bottom of valleys. Major locations include Mehdiabad, Tolti, lower Pari, Ghasing, Manthoka, Madhupur, Kamangu, Kharmang Khas, Susithang, Baghecha.
Cold Temperate Alleviation: 8,000-9,500 feet (2,450-2,900 m) Avg. Temp.: 3.2°C Avg. Prec.: 441 mm	This zone prevails in all main valleys of the district. Major locations include Pari, upper Gundus, Mayurda, Hamzigond, Sinkarmo, Moral.
Sub Alpine Cold Temperate Alleviation: 9,500-10,500 feet (2,900-3,200 m) Avg. Temp.: -3.5°C Avg. Prec.: 339 mm	This zone is stretched in remote parts of the district. Main area are Olding, Torghun, Ganokh, Kendrik, Katisho, Inguth, Mamosh Thang.
Alpine Cold Temperate Alleviation: 10,500-12,500 feet (3,200-3,800 m) Avg. Temp.: -4.0 °C Avg. Prec.: 259 mm	This is the largest zone stretched in remote parts of the district. Main areas are Tololing, Dapa, Donga, Harghosil, Memosh, upper Kendrik
High Alpine and Glaciers Alleviation: 12,500 feet + (3,800 m +) Avg. Temp.: -7.1 °C Avg. Prec.: 227 mm	Areas above 3500 meters above sea level and higher. This is an area which is only used as high-altitude pastures and not for crops.

Figure 3. Percentage area under various AEZs



7. Agricultural potential

It is important to note that in an irrigated agriculture system with 4-5 months of summer, most crops may be grown in most of the zones except for the Alpine Cold Temperate zone where fruits and wheat do not ripe due to short growing season. However, some crops grow well in some zones compared to others. The recommendations therefore are based on what could grow well giving best yields, and not on which crops are grown at present. Kharmang also has a high potential for production of seed potato, onion seed and bulb production (gladiolas, lilium, tulip, daffodils). In addition to introducing an appropriate cropping pattern, soil fertility management and erosion control are imperative in Kharmang due to soil characteristics described earlier. The following potential has been identified after consultations with the Agriculture Department and the farming community as well as assessing the market potential and changing climate pertaining to various AEZs of the district (**Table 8**).

Table 8. Potential of crops in various AEZs

Type	Potential crops	Remarks
Potential in Transitional Warm & Cold Temperate zone		
Cereals[7]	Barley, millet, buckwheat	Wheat, which is cultivated in spring in this zone, must shift to winter. Interested farmers will need support in accessing right seed. This will make limited agricultural lands available for other high value crops in summer. Among cereals for summer, barley followed by buckwheat or millet may be a good choice.
Vegetables	Peas, turnip, Potato	Major vegetables in Kharmang include turnip and peas. Other vegetables include potato, cauliflower, onion, and garlic. Farmers may decide to either grow winter wheat or leave the land fallow during winter for cultivating different vegetables or potato in the spring.
Fruit	Apple, apricot, pear	Apple, apricot, and pear are niche fruits of Kharmang with high economic gain. Potential fruits to promote include cherry, peach, almond, and walnut.
Fodder	Barley / millet	Barley-millet are cultivated mainly for fodder
Potential in Cold Temperate zone		
Cereals	Barley, buckwheat	Buckwheat may be a high economic potential for Kharmang but in this zone it competes with Barley.
Vegetables	Potato, Peas, and turnip	Major vegetables in Kharmang include turnip and peas. Other vegetables include potato, and red beans.
Fruit	Apricot, apple, pear	Apricot, apple, and pear are significant in this zone. Other fruits grown by further promotion include cherry, peach, almond and walnut. Mulberry grows in abundant, there is a high potential to add value to the existing red mulberry.
Fodder	Irrigated natural pastures and crop by-products	No specific cultivation
Potential in Sub Alpine Cold Temperate zone		
Cereals	Barley	Either barley or buckwheat may be cultivated in this zone due to short duration cultivation season
Vegetables	Potato, Turnip	Turnip is high potential crop in this zone. Peas and potato may be cultivated with good production.
Fruit	Apricot	Apricot is encouraged for oil extraction only
Fodder	Natural pastures and crop by-products	No specific cultivation
Potential in Alpine Cold Temperate zone		
Cereals	Barley	The growing season in this zone is too short and may support barley cultivation only
Vegetables	Potato, Turnip	Turnip, with option for peas and potato within the short growing season
Fruit	None	Not suited for fruits
Fodder	Natural pastures and crop by-products	No specific cultivation

[7] Barley-millet are cultivated as two short crops to cover for cereal and fodder requirements in this zone. This may be replaced by barley-buckwheat to cover for fodder as well as cash

Agro-Ecological Zones

Nagar

Latitude 27.4242° N and Longitude 77.0996° E

1. Introduction

District Nagar is situated in the Gilgit region. The district is spread over an area of 4137 sq.km (413,700 ha) which is 4.73% of the total area of Gilgit-Baltistan (GB)[1]. Nagar is bounded by district Hunza on the north and north-east, by district Shigar on the south-east, by district Gilgit on the south and district Ghizer on the west. The district headquarter is the town of Sikandar Abad. Administratively, Nagar district consists of three tehsils: Nagar-I, Nagar-II and Shanibar[2]. The population of the district in 2017 was 70,000 with 9,091 households at an average household size of 7.7[3] dwelling in 39[4] villages. With a population growth rate of 1.64[5], the estimated population of the district in 2022 is 75,931. The overall literacy rate in the district is 66% - male 78%, female 57%[6].

2. Land use statistics

According to Agriculture Department GB, the total agricultural land of the district is 3,458 ha out of which 1,529 ha is cultivated while 1,929 ha is cultivable waste[7]. The land use statistics of district Nagar are given in **Table 1**.

Table 1. Land use statistics

S.No.	Type of Land	Area (Ha)	Percentage
1.	Agricultural Land	3,458	0.8%
2.	Forest Land	6,377	1.5%
3.	Range Land & Pastures	48,756	12%
4.	Rivers/Lakes	13,844	3.4%
5.	Built up Area	32,227	0.8%
6.	Snow/Glaciers	137,397	33.2%
7.	Rocks	200,641	48.3%
	Total	**413,700**	**100%**

Source: Calculated using GIS tools based on district shape files provided by GB Agriculture department 2022

3. Current features of agriculture

The crops grown and cropping pattern in Nagar is influenced by the elevation which ranges from about 2000 meters (m) to above 3000 m as sowing and harvesting varies from zone to zone. In the lower parts of the district double cropping system is practiced while in the upper parts single cropping pattern is followed. The major cereal crops of the districts are maize and wheat. However, barley and buckwheat are also produced which are diminishing. The vegetables grown are potato, tomato, peas, cabbage, cucumber, carrot, radish, okra, and beans. The fruits of the districts are apricot, cherry, apple, grapes, pear, peaches, pomegranate, mulberry, walnut and almond. Fodder is also produced in sufficient quantity. It is important to mention that farmers grow multiple crops for subsistence in the same season. The typical cropping pattern followed in the district is given in **Table 2.**

Table 2. Current cropping pattern

Altitude (m) and major locations (examples)	Cropping pattern
Altitude: 2000 to below 2590 **Cropping season:** Feb/Mar – Oct Double cropping **Major locations:** Chalt, Sikandar Abad, Jafarabad, Sonikot, Rabat, Akbarabad, Budlas, and Minapin, Askurdas, Nagar Khas, Sumayr, Bar, Nilt, Miachar, Dadimal, Balakot, Hakuchar, Chaprot.	• Wheat followed by maize, and vegetable and fodder – OR • Wheat followed by barley, and vegetables and fodder – OR • Wheat followed by buckwheat, and vegetables and fodder – OR • Potato, and vegetable and fodder • Fruits are grown on large scale • Fodder is grown as irrigated perennial crop in limited area
Altitude: 2590 and above **Cropping season:** Apr – Oct Single cropping **Major locations:** Hoper, Bar Khas, Hispar, Fekar, Diater valley, Pissan, Gulmit, Gappa valley, upper Chaprot, Hapakun Hoper	• Wheat followed by buckwheat, and vegetables and fodder – OR • Potato, and vegetables and fodder – OR • Wheat, and vegetables and fodder – OR • Barley followed by buckwheat, and vegetables and fodder • Fruits are grown on large scale in lower altitudes and in limited quantities in higher altitudes • Fodder is grown as irrigated perennial crop, less in lower altitudes and more on higher altitudes

Source: Primary data from consultation workshops and interviews June 2022

[1] GB at a glance 2020. Government of Gilgit Baltistan
[2] Noted by the department staff however demarcation is not available, therefore not indicated on GIS maps used in this document
[3] GB at a glance 2020. Government of Gilgit Baltistan
[4] Agriculture Survey Report 2014 – Gilgit Baltistan
[5] https://www.citypopulation.de/en/pakistan/cities/gilgitbaltistan
[6] GB at a glance 2020. Government of Gilgit Baltistan
[7] Agriculture Census 2020, department of Agriculture Gilgit Baltistan

4. Soil characteristics

Nagar's soil consists of Gleysols and Lithosols as parent material. Most of the agriculture takes place on Lithomorphic soils in Nagar I. The Agro-ecological zonation map also shows that most of the area is on lithomorphic soils. Gley soils prevail at high elevations not suitable for agriculture, or these constitute marshy grounds and lakes on shared borders with districts Gilgit, Hunza, Shigar and Ghizer. Lithomorphic soils are thin (less than 30cm deep) with slowly weathering coarse textured parent material, highly prone to land degradation and erosion. Sustainable crop production is only possible with good erosion control measures. These soils are surrounded by Gley soils and are indeed fed by water from Gleysols grounds. Gley soils are found on higher altitudes with pastures and glacial reserves on elevations 3500 m and above.

Sandy clay loam is a prominent soil texture found in Nagar followed by sandy loam. Organic matter is adequate in lithosol areas with neutral to slightly alkaline pH ideal for vegetable and fruit production. **Table 3** summarises soil characteristics of Nagar.

Table 3. Summary of soil characteristics

Parent material	Organic Matter (%)	Fertility			Soil texture			pH
		NO3-N (mg kg^{-1})	P (mg kg^{-1})	K (mg kg^{-1})				
Gleysols 60% Lithosols 40%	Adequate	Low	Low	Low	Silty clay loam 50%	Loam 25%	Sandy loam 25%	Slightly alkaline

5. Climate trends

The average day time temperature has increased from 5.7°C to 6.3°C since 1991. This is a nominal increase of 0.6°C in thirty years. Most of this increase was noted in spring season. The average night temperature has increased from -5.7°C to -4.3°C since 1991. This is a rise of 1.4°C in thirty years. Nights have become warmer in all the months. The increase in night temperatures is greater compared to day temperatures in the spring months. This results in hotter springs setting early allowing early sowing of crops. Autumn has also become warmer since 1960. Warmer springs and autumns provide an opportunity to introduce double cropping in some areas.

Overall, precipitation has decreased. This decrease is mainly recorded in the spring and autumn against the base year of 1960. During the last three decades, precipitation also reduced in summers, however, slightly increasing during autumn. In spring season more water will be available due to early onset of snowmelt due to increase in temperatures. Reduced rains and higher temperatures in spring season may increase dependence of agriculture on irrigation.

Following sub sections provide details on day and night temperatures (**Tables 4 and 5**), and precipitation (**Table 6**). The analysis in these sections is based on average conditions. There may be year to year variations (e.g., cold wave during spring, or wetter than average or drier than average). This climate variability is not accounted for in ascertaining climate change trend.

5.1 Analysis of maximum temperature

- Mean monthly day time temperature during the winter months is increasing. A major change is in the month of January. In case of December temperature had increased after 1960 but decreased since 1991.
- Day temperatures in spring season are increasing at the highest rate among all seasons. The largest increase is noted in March with 2.2°C increase since 1991.
- Day temperatures in summers have increased since 1991 to varying degrees, maximum increase is recorded in July.
- Day temperatures in autumn are overall increasing. Temperature in November shows a decline since 1991 after increasing in the previous 30 years. Overall, autumn has become warmer since 1960.

Table 4. Trend analysis of mean monthly maximum temperature (°C)

	1960-2020			1960-1990			1991-2020		
Months	Change from - to	Change in temperature	Trend	Change from - to	Change in temperature	Trend	Change from - to	Change in temperature	Trend
Dec	-4.9 to -4.6	0.3	↑	-5.2 to -4.4	0.8	↑	-4.2 to -4.8	-0.6	↓
Jan	-7.7 to -7.5	0.2	↑	-8 to -7.1	0.9	↑	-8.2 to -7.2	1	↑
Feb	-6.6 to -5.2	1.4	↑	-6.4 to -6.3	0.1	↑	-5.7 to -5.3	0.4	↑
Mar	-1 to 0.5	1.5	↑	0 to -1.3	-1.3	↓	-0.9 to 1.3	2.2	↑
Apr	5.1 to 6.5	1.4	↑	5.1 to 6.1	1	↑	5.3 to 6.9	1.6	↑
May	9 to 9.9	0.9	↑	8.9 to 9.8	0.9	↑	9.2 to 10.1	0.9	↑
Jun	14.5 to 14	-0.5	↓	14.7 to 14.1	-0.6	↓	13.8 to 14.4	0.6	↑
Jul	17.9 to 17.9	0	↔	18 to 18	0	↔	17.6 to 18.3	0.7	↑
Aug	17.7 to 17.5	-0.2	↓	17.6 to 17.6	0	↔	17.4 to 17.6	0.2	↑
Sep	14.2 to 14.5	0.3	↑	14 to 14.8	0.8	↑	14.2 to 14.6	0.4	↑
Oct	7.9 to 8.5	0.6	↑	8 to 8.1	0.1	↓	7.8 to 8.8	1	↑
Nov	0.8 to 2.1	1.3	↑	0.3 to 1.8	1.5	↑	2.2 to 1.5	-0.7	↓

5.2 Analysis of minimum temperature

- Mean monthly night temperatures during winter months have increased during the last 30 years. From 1960, this increase is between 1.4°C and 1.7°C.
- Spring nights are warming up fast with the most significant change noted in March and April.

- Summer nights are also becoming warmer as the night temperatures are increasing more than the day temperatures with a maximum change observed in the months of June, August and September.
- As in case of other seasons similar warming trend is observed in autumn with the highest increase in October. Autumn is starting late and becoming milder.

Table 5. Trend analysis of mean monthly minimum temperature (°C)

	1960-2020			1960-1990			1991-2020		
Months	Change from - to	Change in temperature	Trend	Change from - to	Change in temperature	Trend	Change from - to	Change in temperature	Trend
Dec	-14.6 to -13.2	1.4	↑	-15.3 to -13.2	2.1	↑	-13.2 to -13.9	-0.7	↓
Jan	-17.6 to -16	1.6	↑	-18 to -16.3	1.7	↑	-16.9 to -16.1	0.8	↑
Feb	-16.2 to -14.5	1.7	↑	-15.8 to -16	-0.2	↓	-15.2 to -14.4	0.8	↑
Mar	-10.9 to -8.6	2.3	↑	-10.5 to -10.3	0.2	↓	-10.3 to -8.1	2.2	↑
Apr	-5.9 to -3.9	2	↑	-5.7 to -5	0.7	↑	-5.7 to -3.3	2.4	↑
May	-3.2 to -1	1.2	↑	-3.1 to -2.1	1	↑	-2.4 to -0.8	1.6	↑
Jun	1.6 to 2.5	0.9	↑	2 to 1.7	-0.3	↓	1.8 to 2.7	1.9	↑
Jul	4.7 to 5.8	1.1	↑	5.2 to 4.9	-0.3	↓	4.7 to 6.3	1.6	↑
Aug	4.4 to 5.7	1.3	↑	4.7 to 4.8	0.1	↓	4.3 to 6.3	2	↑
Sep	-0.1 to 1.4	1.5	↑	0.4 to 0.2	-0.2	↓	0.1 to 2	1.9	↑
Oct	-5.7 to -3.7	2	↑	-5.2 to -5.1	0.1	↓	-5.5 to -3.1	2.4	↑
Nov	-10.8 to -9.5	1.3	↑	-10.9 to -9.8	1.1	↑	-10.2 to -9.5	0.7	↑

5.3 Analysis of precipitation

- In winter season precipitation has increased since 1960 but is stable during the last 30 years.
- Spring precipitation is on steady decline since 1960.
- In summers, precipitation has overall increased since 1960 which started slowing down since 1991.
- Overall, autumn precipitation has slightly reduced since 1960, but is increasing during the last 30 years.

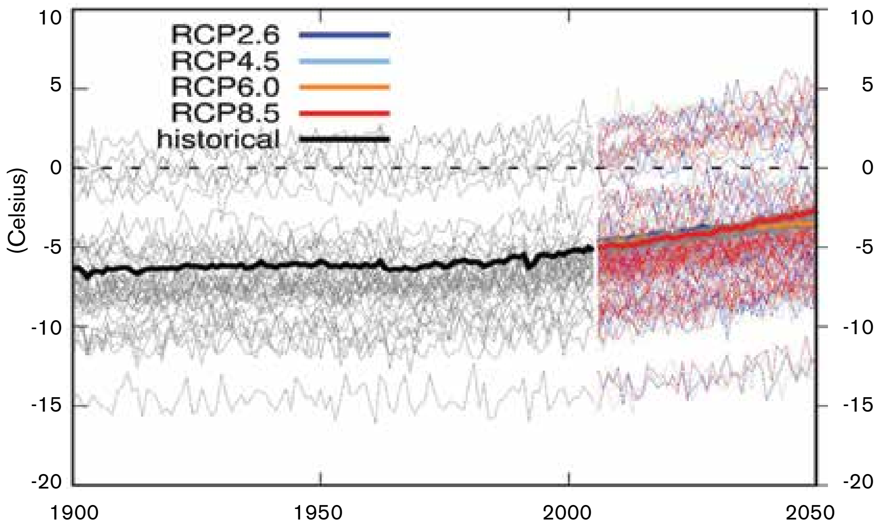
Table 6. Trend analysis of annual and seasonal precipitation (mm)

	1960-2020			1960-1990			1991-2020		
Season	Change from - to	Change in precipitation	Trend	Change from - to	Change in precipitation	Trend	Change from - to	Change in precipitation	Trend
Annual	297 to 296	-1	↓	294 to 297	3	↑	305 to 289	-16	↓
Winter	78 to 91	13	↑	75 to 87	12	↑	87 to 87	0	↔
Spring	136 to 114	-22	↓	143 to 101	-42	↓	131 to 102	-29	↓
Summer	51 to 66	15	↑	47 to 63	16	↑	65 to 60	-5	↓
Autumn	31 to 27	-4	↓	27 to 37	10	↑	21 to 30	9	↑

5.4 Climate scenarios

Figure 1 for near surface temperature presents projections till 2050 based on different emissions scenarios and how these emissions will affect the temperature in Nagar till 2050. Taking the historical trend from 1900, the time series projects that under different GHG emissions reduction scenarios, the mean near surface temperature of Nagar will be between -4°C and -3°C which was around -6°C in 1900. This is a rise of 2°C to 3°C till 2050.

Figure 1. Temperature projection till 2050



Source: IPCC Assessment Report 5 – 2014

6. Agro-ecological zones

District Nagar comprises six Agro-ecological zones (AEZs). **Figure 2** provides an AEZ map which is supported by **Table 7** with major locations per zone. **Figure 3** shows percentage area of the district prevailing in various AEZs. In total, 28% area of the district falls within cultivable limit whereas 72% is beyond agricultural potential.

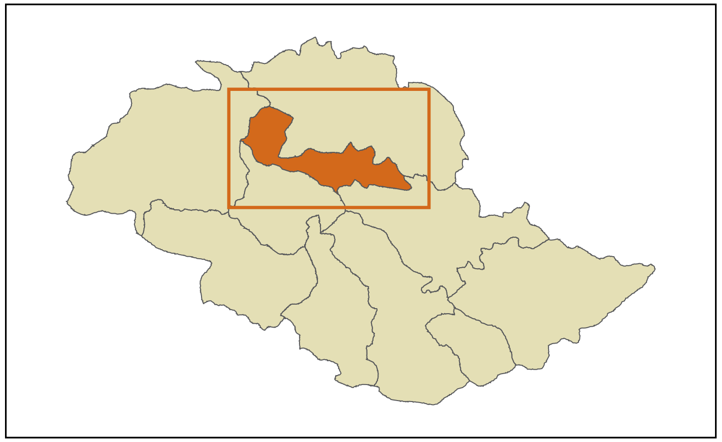


Figure 2. Agroecological zones of Nagar District

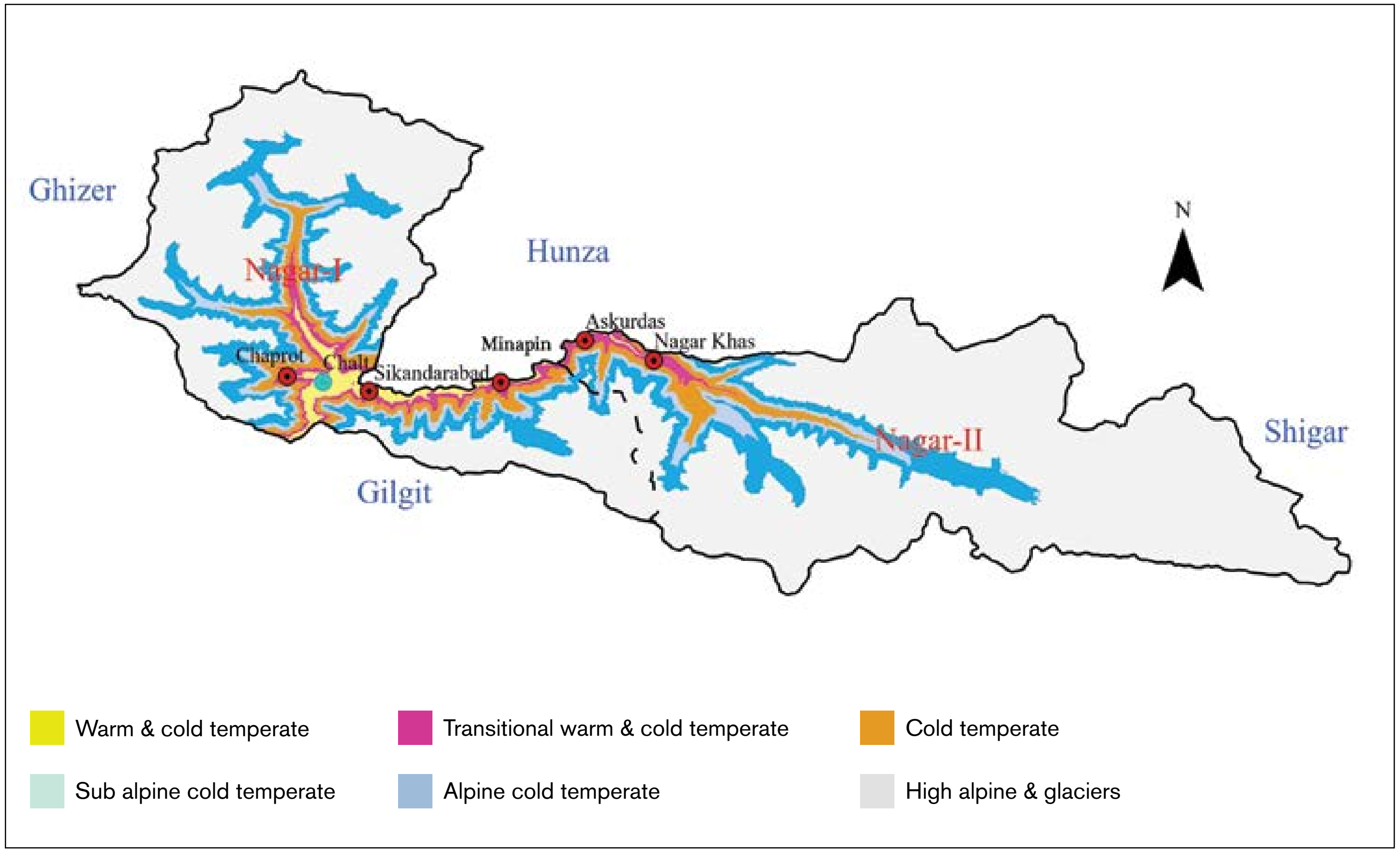
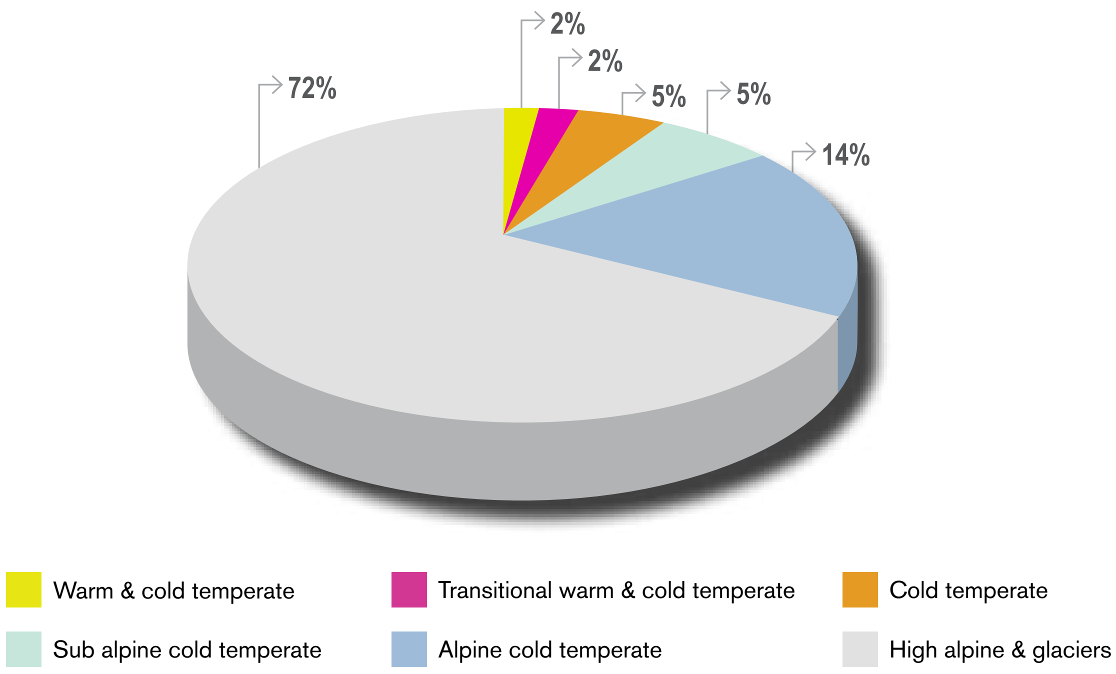


Table 7. Major locations falling in various AEZs

Agro-ecological zones	Major locations
Warm & Cold Temperate Alleviation: 5,500-7,000 feet (1,720-2,150 m) Avg. Temp.: 4.4°C Avg. Prec.: 389 mm	This is a very limited strip where this zone exists in Nagar. Major locations include Chalt, Sikandar Abad, Jafarabad, Sonikot, Rabat, Akbarabad, Budlas, and Lower Minapin
Transitional Warm & Cold Temperate Alleviation: 7,000-8,000 feet (2,150-2,450 m) Avg. Temp.: 3.9°C Avg. Prec.: 419 mm	This is a limited zone mostly in Nagar I, adjoining Hunza and partly in pockets closer to Ghizer. Locations include Askurdas, main Nagar (Nagar Khas), Sumayr, Lower Bar, Upper Minapin, Nilt, Miachar, Dadimal, Balakot, Hakuchar, and Chaprot.
Cold Temperate Alleviation: 8,000-9,500 feet (2,450-2,900 m) Avg. Temp.: 3.2°C Avg. Prec.: 441 mm	Mostly located in Nagar II, major locations include Hoper, Bar upper (khas), lower Hispar, Fekar, lower Diater valley, Pissan, Gulmit, lower Gappa valley
Sub Alpine Cold Temperate Alleviation: 9,500-10,500 feet (2,900-3,200 m) Avg. Temp.: -3.5°C Avg. Prec.: 339 mm	This zone is stretched at higher elevations of the earlier zones including locations of upper Hispar, upper Hopper, upper Bar (Bar Das), upper Chaprot, upper Gappa, upper Diater, Hapakun Hoper
Alpine Cold Temperate Alleviation: 10,500-12,500 feet (3,200-3,800 m) Avg. Temp.: -4.0°C Avg. Prec.: 259 mm	This zone is stretched in remote parts of district beyond settlements at higher altitudes (e.g., Barpu, Hamadar areas of Hoper). This is the largest zone consisting of pastures.
High Alpine and Glaciers Alleviation: 12,500 feet + (3,800 m +) Avg. Temp.: -7.1°C Avg. Prec.: 227 mm	Areas above 3800 meters above sea level and higher. This is an aera which is only used as high-altitude pastures and not for crops. This area comprises Tagafari pastures and Saltars

Figure 3. Percentage area under various AEZs

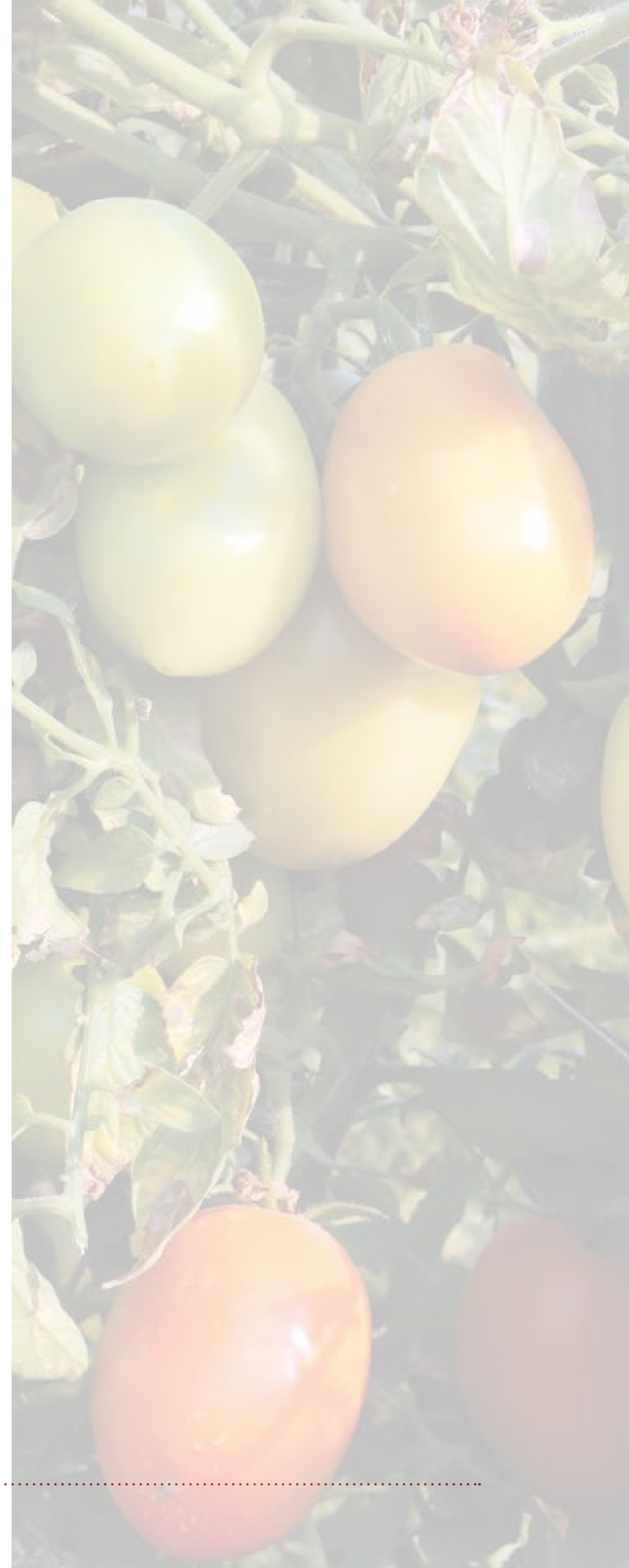


7. Agricultural potential

In an irrigated agriculture system with 4-5 months of summer, most crops may be grown in most of the zones except for the Alpine Cold Temperate zone where fruits and wheat do not ripe due to short growing season. However, some crops grow well in some zones compared to others. The recommendations, therefore, are based on what could grow well giving best yields, and not on which crops are currently grown. In addition to introducing an appropriate cropping pattern, soil fertility management and erosion control are imperative in Nagar due to soil characteristics described earlier. The following potential (**Table 8**) has been identified in consultations with the Agriculture Department and the farming community as well as assessing the climate and market potential pertaining to various AEZs of the district.

Table 8. Potential of crops in various AEZs

Type	Potential crops	Remarks
Potential in Warm & Cold Temperate zone		
Cereals	Wheat (winter sowing), Maize and Quinoa (high potential)	Wheat in winter and maize as a second cereal crop are priority. Quinoa has been proposed as a high potential superfood crop to be grown during summer.
Vegetables	Potato, capsicum, peas	Potato and Capsicum are in high demand in the market. This zone also specializes in Peas, sown in February / March and harvested in May /June which is early harvest having advantage in the market. Red kidney beans are also very successfully produced along peripheries (especially in Chalt). Vertical Tomato is cultivated in May and fruits in July over a long stretch. Cucumber and bottle gourd are also suitable to be cultivated in vertical formation.
Fruit	Cherry, apricot, apple, pears	This zone shows a greater affinity for cherry, apricot, apples, and pears. Apricot is cultivated in relatively small quantity whereas cherry is more popular and highly established to reach the market.
Fodder	Alfalfa	Alfalfa is mostly intercropped for fodder in the orchards.
Potential in Transitional Warm & Cold Temperate zone		
Cereals	Wheat (winter sowing only)	Spring sowing of wheat for subsistence takes place in this zone. Economic potential of wheat compared to vegetables is very low and hence not recommended. Winter sowing is potentially suitable in this zone due to warming temperatures. It is recommended to use this area as high potential for vegetable and fruit production.
Vegetables	Potato, peas, leafy vegetables	Potato is a major crop followed by peas, leafy vegetables, and cabbage. Cucumber and tomato are proposed in vertical farming, with cabbage intercropping (or separately in the field). Carrot is also a high potential crop in this zone.
Fruit	Apricot, Apple, Walnut, Cherry, Pear	Apple is a top fruit in this zone beside walnut, cherry, and pear. Apricot (for drying) and fresh sale.
Fodder	Barley, Maize, Alfalfa	Barley is cultivated at a subsistence level including for fodder. Alfalfa is cultivated separately as well as intercropped with maize, which is also a fodder crop.
Potential in Cold Temperate zone		
Cereals	Wheat	This is spring wheat sowing zone. However, since land is very limited, it is recommended to save land for marketable vegetable crops instead of spring wheat. Barley is cultivated in this zone for fodder.
Vegetables	Potato, peas, carrot, turnip	Table potato and seed potato are both high potential crops in this zone. Besides, peas is a highly viable cash crop. This zone is also suitable for producing carrot. A high potential crop may be red kidney beans (Faba beans) along periphery or intercropped with orchards. Cucumber and tomato are proposed in vertical farming, with cabbage intercropping (or separately in the field).
Fruit	Apricot, apple, walnut	Fresh and dried apricots are produced in this zone. Other high potential fruit crops include apples and walnut.
Fodder	Barley, alfalfa	Barley is suitable for cultivation as fodder. Alfalfa is cultivated along peripheries, in the fields, and intercropping with orchards.



Potential in Sub Alpine Cold Temperate zone		
Cereals	None	Economic potential of wheat when compared to vegetables is very low and not recommended. It is recommended to use this area as high potential for vegetable production.
Vegetables	Potato, peas, leafy vegetables, turnip	Table potato and seed potato are both high potential crops in this zone. Besides, peas are viable cash crops. This zone is also suitable for producing leafy vegetables and turnip. A highly potential crop may be red kidney beans (Faba beans) along periphery or intercropped with orchards.
Fruit	None	
Fodder	Alfalfa, barley	Mostly this zone is catered by natural pastures. Main cultivated fodder in this zone is alfalfa. In addition, short duration barley may be cultivated for fodder.
Potential in Alpine Cold Temperate zone		
Cereals	None	
Vegetables	Peas, turnips	Although there is very little cultivation in this zone. Peas and turnip, however, are short duration crops that may be cultivated.
Fruit	None	
Fodder	Natural pastures and crop by-product	No specific cultivation

Agro-Ecological Zones

Shigar

Latitude 35.4765° N and Longitude 75.6964° E

1. Introduction

District Shigar is situated in the Baltistan region. The district is spread over an area of 4,173 sq.km (417,300 ha), which is 6% of the total area of Gilgit-Baltistan (GB)[1]. Shigar is bounded on the north by the Nagar and Hunza districts, on the south-east by the Ghanche district, on the south-west by the Skardu and on the west by the Gilgit district. The district headquarters are located in the town of Shigar. The district starts from an elevation of 2,225 meter (m). The district is gateway to the majestic mountain range of Karakoram including 5 eight-thousanders of the world including mount K2. Administratively, Shigar is composed of a single tehsil namely Shigar. The total population in 2017 was 70,000 with 8,974 households at an average household size of 7.8[2]. The number of villages is 57[3]. With a growth rate of 2.31[4], the estimated population of the district in 2022 is 78,467 persons. The overall literacy rate is 46% - male 58% and female 36%[5].

2. Land use statistics

According to Agriculture Department GB, the total agricultural land of the district is 5,539 ha, out of which 3,551 ha is cultivated whereas 1,988 ha is cultivable waste[6]. The land use statistics of district Shigar are given in **Table 1**.

Table 1. Land use statistics

S.No.	Type of Land	Area (Ha)	Percentage
1.	Agricultural Land	5,539	1.3%
2.	Forest Land	5,192	1.2%
3.	Range Land & Pastures	570,122	16.8%
4.	Rivers/Lakes	15,217	3.7%
5.	Built up Area	3,005	0.7%
6.	Snow/Glaciers	172,858	41.4%
7.	Rocks	145,367	34.9%
	Total	**417,300**	**100%**

Source: Calculated using GIS tools based on district shape files provided by GB Agriculture department 2022

3. Current features of agriculture

The crops grown and cropping pattern in Shigar are influenced by the elevation which ranges from about 2,200 meters (m) to above 3,000 m as sowing and harvesting varies from zone to zone. Single cropping pattern is practiced in most of the district. However, buckwheat is grown after barley in some areas. The major cereal crops of the district are wheat, barley, maize, and buckwheat. The vegetables grown are potato, peas, tomato, cucumber, Chinese cabbage, radish, and carrot. The fruits of the districts include apricot, apple, mulberry, walnut, cherry, pear, peaches, and almond. Fodder is also produced in sufficient quantity. It is important to note that farmers grow multiple crops for subsistence in the same season. A typical cropping pattern followed in Shigar is given in **Table 2**.

Table 2. Current cropping pattern

Altitude (m) and major locations (examples)	Cropping Pattern
Altitude: 2200 to below 2500 **Cropping season:** Late March–September Single cropping **Major locations:** Shigar proper to Haiderabad, Niali to Chutron	• Wheat followed by fodder – OR • Barley followed by buckwheat – OR • Barley followed by beans – OR • Potato – fallow • Vegetable grown parallel to crops • Fodder as irrigated perineal crop on small scale • Fruits are extensively grown
Altitude: 2500 to below 3000 **Cropping season:** April–Sep Single cropping **Major locations:** Dasso Shigar to Appo Ali gons, Zil, Basha, Dogro	• Wheat – fallow – OR • Barley followed by buckwheat – OR • Barley followed by vegetables – OR • Potato – fallow • Vegetable grown parallel to crops on small scale • Fodder as irrigated perineal crop on small scale • Fruits are extensively grown
Altitude: Above 3000 **Cropping season:** May–Sep Single cropping **Major locations:** Askoli, Tistee, Upper Braldo, Arindo Bisil	• Wheat - fallow – OR • Barley - fallow – OR • Buckwheat – fallow - OR • Potato – fallow • Vegetable (beans, peas) grown parallel to crops on small scale • Fodder as irrigated perineal crop on small scale • Main fruit apricot and mulberry

Source: Primary data from district workshops and interviews

4. Soil characteristics

The Gleysols, Lithosols and Cambisols are main soils Shigar. Gley soils are on high altitude along borders with Nagar, Hunza and a bit with Ghanche. These soils are located at high altitudes and mostly covered with ice lakes and glacial reserves and do not support any kind of agricultural activity.

Lithomorphic soils are located through the middle length of the district in patchy distribution. Lithomorphic soils are thin (less than 30cm deep) with

[1] GB at a glance 2020. Government of Gilgit Baltistan
[2] Ibid
[3] Agriculture Statistics Report 2014. Gilgit Baltistan
[4] https://www.citypopulation.de/en/pakistan/cities/gilgitbaltistan
[5] GB at a Glance 2020. Government of Gilgit Baltistan
[6] Agriculture Census 2020, department of Agriculture Gilgit Baltistan

slowly weathering coarse textured parent material, highly prone to land degradation and erosion. Sustainable crop production is a challenge on these soils since these soils need a lot of care and conservation measures. More attention is required for its conservation; if this shallow soil is lost, it will be a long weathering process before new soil is formed. These soils prevail along borders with Skardu and Ghanche. There is a single patch of Eutric Cambisol on border with Skardu stretched through Skardu centre and middle length of Kharmang. Cambisols are highly productive soils. This is where most of rich agricultural activity prevails.

An appreciable amount of organic matter was found in soil samples collected from district Shigar. It was observed that the silty clay loam texture was a dominant type in district Shigar. **Table 3** summarises major soil characteristics of the district.

Table 3. Summary of soil characteristics

Parent material	Organic Matter (%)	Fertility			Soil texture			pH
		NO3-N (mg kg^{-1})	P (mg kg^{-1})	K (mg kg^{-1})				
Gleysols 45% Lithosols 40% Cambisols 15%	Adequate	Low	Low	Low	Silty clay loam 65%	Sandy loam 25%	Silt loam 10%	Neutral to slightly Alkaline

5. Climate trends

Of all the districts in GB, the highest increase in temperatures is observed in Shigar. The average day time temperature of Shigar has increased from 2.9°C to 3.4°C since 1991. The biggest increase has been noted in the spring season. The summer temperatures are not increasing at the same rate as winter and spring seasons. Increased temperature in the month of October suggests that autumn may be starting late and becoming milder. The nights in Shigar are becoming warmer in all the months at a faster rate than the days. The increase in night temperatures is more as compared to day temperatures particularly in the spring months, making springs warmer.

Warmer spring and autumn seasons are expanding the crop growing season and provide opportunity to the farmers to convert some of the areas into marginally double cropping zone. Warmer spring may not allow the snow to consolidate and can initiate early snowmelt due to rise in temperature resulting in flash floods during the spring season. At the same time, more water may be available due to early onset of snowmelt. Warmer weather in spring may allow early sowing of crops.

Overall precipitation has increased between 1960-1990 in Shigar. During the last 30 years (1991-2020), however, the precipitation trend is negative and has returned to the level of 1960. During the period 1991-2020, spring and summer rains are on a decline whereas winter and autumn precipitation is slightly increasing.

Following sub sections provide details on day and night temperatures (**Tables 4 and 5**), and precipitation (**Table 6**). The analysis in these sections is based on average conditions. There may be year to year variations (e.g., cold wave during spring, or wetter than average or drier than average). This climate variability is not accounted for in ascertaining climate change trend.

5.1 Analysis of maximum temperature

- Mean monthly day time temperature during the winter months is consistently increasing. A major increase is noted in the month of February whereas temperature in January is also increasing. In case of December, though the temperature has increased with respect to 1960, but it is showing a declining trend since 1991.
- Day temperatures in spring season are increasing with the fastest rate among all seasons. The biggest increase is noted in the months of March and April, i.e., an increase of 1.9°C and 1.7°C, respectively since 1991.
- Day temperatures in summers show a consistently increasing since 1991 to varying degrees with maximum increase recorded in June and July.
- Day temperatures in autumn are increasing for October whereas November is showing declining trend since 1991. Overall, autumn has become warmer since 1960.

Table 4. Trend analysis of mean monthly maximum temperature (°C)

	1960-2020			1960-1990			1991-2020		
Month	Change from - to	Change in temperature	Trend	Change from - to	Change in temperature	Trend	Change from - to	Change in temperature	Trend
Dec	-7.3 to -6.8	0.5	↑	-7.4 to -7	0.4	↑	-6.7 to -7.1	-0.4	↓
Jan	-10.2 to -10.2	0	↔	-10.4 to -9.7	0.7	↑	-10.6 to -9.9	0.7	↑
Feb	-9.2 to -8.1	1.1	↑	-9 to -9	0		-8.3 to -8	0.3	↑
Mar	-3.8 to -2.2	1.6	↑	-2.7 to -4.1	-1.4	↓	-3.6 to -1.5	1.9	↑
Apr	2 to 3.6	1.6	↑	2.1 to 2.8	0.7	↑	2.2 to 3.9	1.7	↑
May	5.6 to 6.7	1.1	↑	5.6 to 6.3	0.7	↑	5.9 to 6.8	0.9	↑
Jun	11.1 to 10.5	-0.6	↓	11.4 to 10.5	-0.9	↓	10.5 to 10.8	0.3	↑
Jul	15.2 to 15.2	0	↔	15.3 to 15.2	-0.1	↓	15 to 15.3	0.3	↑
Aug	15 to 14.5	-0.5	↓	14.9 to 14.8	-0.1	↓	14.6 to 14.5	-0.1	↓
Sep	11.5 to 11.7	0.2	↑	11.3 to 11.8	0.5	↑	11.5 to 11.7	0.2	↑
Oct	4.8 to 5.3	0.5	↑	5.2 to 4.8	-0.4	↓	4.8 to 5.8	1	↑
Nov	-2.2 to -0.8	1.4	↑	-2.3 to -1.4	0.9	↑	-0.8 to -1.3	-0.5	↓

5.2 Analysis of minimum temperature

- Mean monthly night temperatures during winter months are overall increasing in the last 60 years. In the period from 1960 this increase is between 1.6°C and 2°C. The night temperatures for December increased in the period 1960 to 1990, however shows a decreasing trend since 1991.
- Warmer February and March suggests an early onset of spring season. Since 1960, the nights have become warmer by 2.5°C. The increase is higher during the last 30 years. The rate of increase in night temperatures is more when compared to the increase in day temperatures in the spring months making springs warmer.
- Summer nights are also becoming warmer as the night temperatures are increasing more than the day temperatures similar to the observation made in spring, with a maximum change observed in August and September.
- Due to increased temperature in October, the autumn is shrinking and is getting milder.

Table 5. Trend analysis of mean monthly minimum temperature (°C)

	1960-2020			1960-1990			1991-2020		
Months	Change from - to	Change in temperature	Trend	Change from - to	Change in temperature	Trend	Change from - to	Change in temperature	Trend
Dec	-18.5 to -16.5	2	↑	-18.9 to -17.1	1.8	↑	-16.9 to -17.1	-0.2	↓
Jan	-21.2 to -19.6	1.6	↑	-21.6 to -19.8	1.8	↑	-20.4 to -19.8	0.6	↑
Feb	-19.9 to -18.1	1.8	↑	-19.4 to -19.6	-0.2	↓	-18.8 to -18.1	0.7	↑
Mar	-14.8 to -12.3	2.5	↑	-14.2 to -14	-0.2	↓	-14 to -11.2	2.8	↑
Apr	-9.8 to -7.4	2.4	↑	-9.3 to -8.9	0.4	↑	-9.5 to -6.8	2.7	↑
May	-7.3 to -4.9	2.4	↑	-7.2 to -6.3	0.9	↑	-6.5 to -4.7	1.8	↑
Jun	-2.1 to -0.9	1.2	↑	-1.5 to -2.1	-0.6	↓	-1.9 to -0.5	1.4	↑
Jul	1.4 to 2.6	1.2	↑	2 to 1.4	-0.6	↓	1.6 to 3.2	1.6	↑
Aug	1.2 to 2.5	1.3	↑	1.7 to 1.5	-0.2	↓	1.2 to 3.2	2	↑
Sep	-3.2 to -1.7	1.5	↑	-2.5 to -3.2	-0.7	↓	-3.1 to -1	2.1	↑
Oct	-9.1 to -7.1	2	↑	-8.4 to -8.8	-0.4	↓	-9 to -6.2	2.8	↑
Nov	-14.7 to -13	1.7	↑	-14.5 to -13.9	0.6	↑	-14.2 to -12.7	1.5	↑

5.3 Analysis of precipitation trend

- Overall, average annual precipitation of Shigar is declining. Major reduction in precipitation is observed in the spring season.
- Precipitation has increased since 1960 in winter season.
- Overall precipitation in summers has increased since 1960 which has however slowed down since 1991.
- Precipitation in autumn has remained stable since 1960 which slightly increased during the last 30 years.

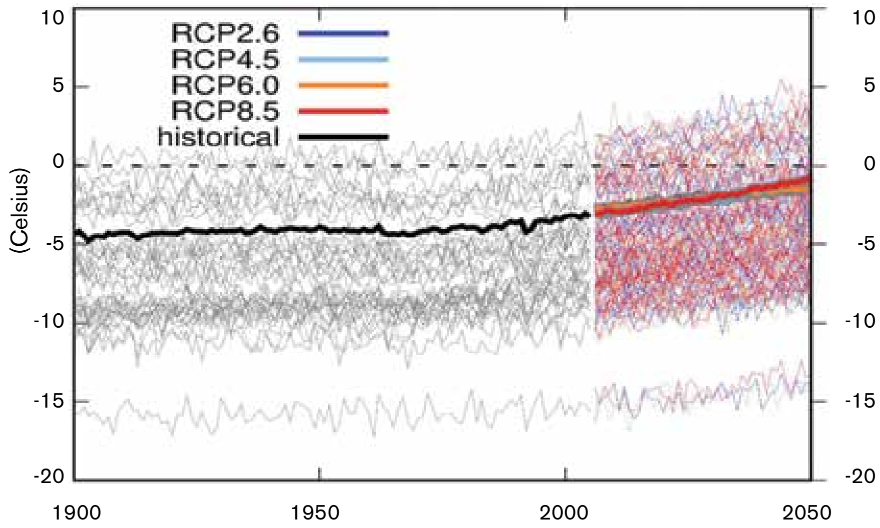
Table 6. Trend analysis of annual and seasonal precipitation (mm)

	1960-2020			1960-1990			1991-2020		
Season	Change from - to	Change in precipitation	Trend	Change from - to	Change in precipitation	Trend	Change from - to	Change in precipitation	Trend
Annual	257 to 268	11	↑	244 to 276	32	↑	274 to 256	-18	↓
Winter	74 to 88	14	↑	68 to 88	20	↑	83 to 86	3	↑
Spring	122 to 110	-12	↓	122 to 110	-12	↓	130 to 102	-28	↓
Summer	32 to 45	13	↑	28 to 41	13	↑	43 to 40	-3	↓
Autumn	30 to 30	0	↔	25 to 38	13	↑	18 to 28	10	↑

5.4 Climate scenarios

Figure 1 for near surface temperature presents projections till 2050 based on different emissions scenarios (as explained in the methodology) and how these emissions will affect the temperature in Shigar. Taking the historical trend from 1900, the time series projects that under different GHG emissions reduction scenarios, the mean near surface temperature of Shigar will remain between -2°C and -1°C which was around -4°C in 1900. This shows further warming in Shigar.

Figure 1. Temperature projection till 2050



Source: IPCC Assessment Report 5 – 2014

Impact of climate change include the following:

- All seasons, days, and nights, are warming
- Warmer spring provides an opportunity for early sowing
- Similarly, a late autumn and delayed onset of harsh winter extends the growing season.
- Early snowmelt makes water available for agriculture. However, this may cause localised flash floods and debris flow

6. Agro-ecological zones

District Shigar comprises five Agro-ecological zones (AEZs). **Figure 2** provides an AEZs map which is supported by **Table 7** showing major locations per zone. **Figure 3** shows percentage area of the district prevailing in various AEZs.

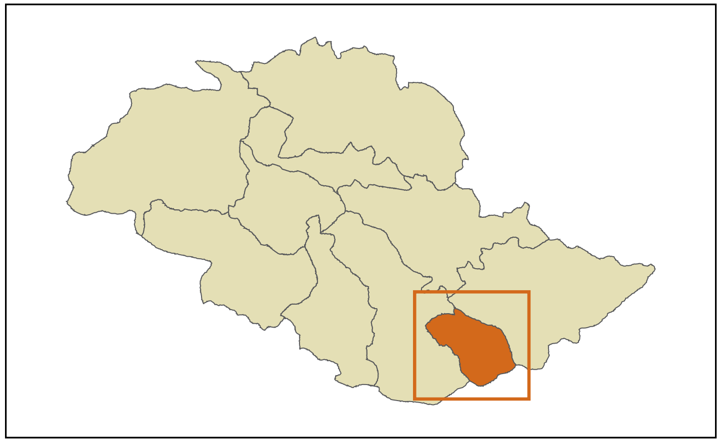


Figure 2. Agroecological zones of Shigar District

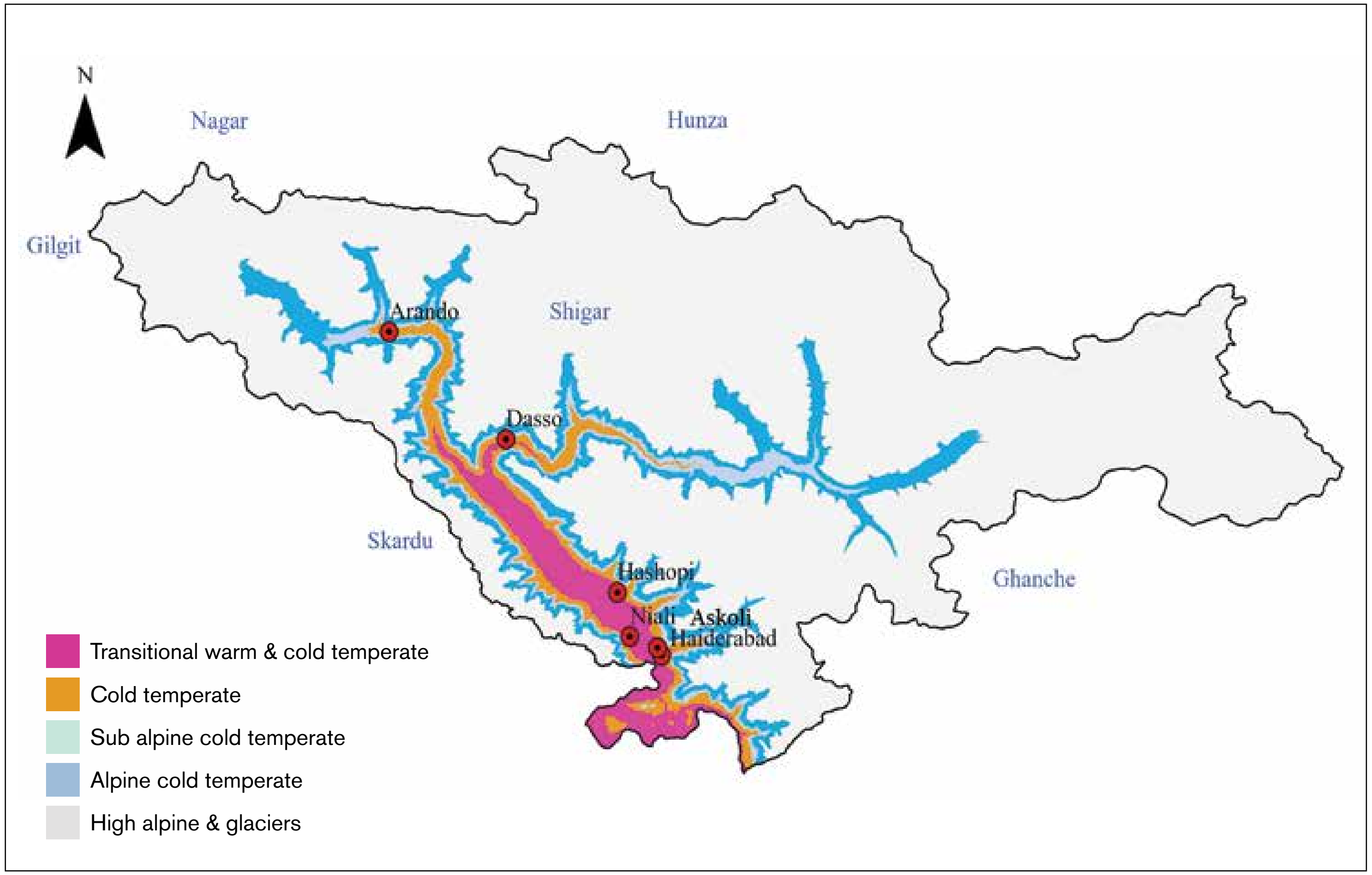


Table 7. Major locations falling in various AEZs

Agro-ecological zones	Major locations
Transitional Warm & Cold Temperate Alleviation: 7,000-8,000 feet (2,150-2,450 m) Avg. Temp.: 3.9°C Avg. Prec.: 419 mm	This zone is in areas adjoining Skardu. Major locations include Sarfaranga, Lamsa, Kothang, Churka, Nar Ghoro, Narbocho, Markenja, Alchori, Hashupi, Hurchus, Sildi, Kashmal, Yono, Hyderabad, Baha, Tesar lower, Gulabpur, Wazirpur, Lagaf
Cold Temperate Alleviation: 8,000-9,500 feet (2,450-2,900 m) Avg. Temp.: 3.2°C Avg. Prec.: 441 mm	This zone is in areas adjoining Skardu at a relatively higher altitude from transitional temperate zone. Major locations include Dasu, Lower Braldo (Apoaligons, Folju), Lower Basha (Chutrun, Thorgo, Damel, Zil, Doko)
Sub Alpine Cold Temperate Alleviation: 9,500-10,500 feet (2,900-3,200 m) Avg. Temp.: -3.5°C Avg. Prec.: 339 mm	This zone is stretched in remoter parts of district. Upper Braldo (Askoli, Tiston), Upper Basha (Besil, Arandu)
Alpine Cold Temperate Alleviation: 10,500-12,500 feet (3,200 -3,800 m) Avg. Temp.: -4.0 °C Avg. Prec.: 259 mm	This zone is stretched further in remoter parts of district. This is the largest zone that prevails on higher altitudes. This zone mainly constitutes pastures.
High Alpine and Glaciers Alleviation: 12,500 feet + (3,800 m +) Avg. Temp.: -7.1°C Avg. Prec.: 227 mm	Areas above 3500 meters above sea level and higher. This is an area which is only used as high-altitude pastures and not for crops.

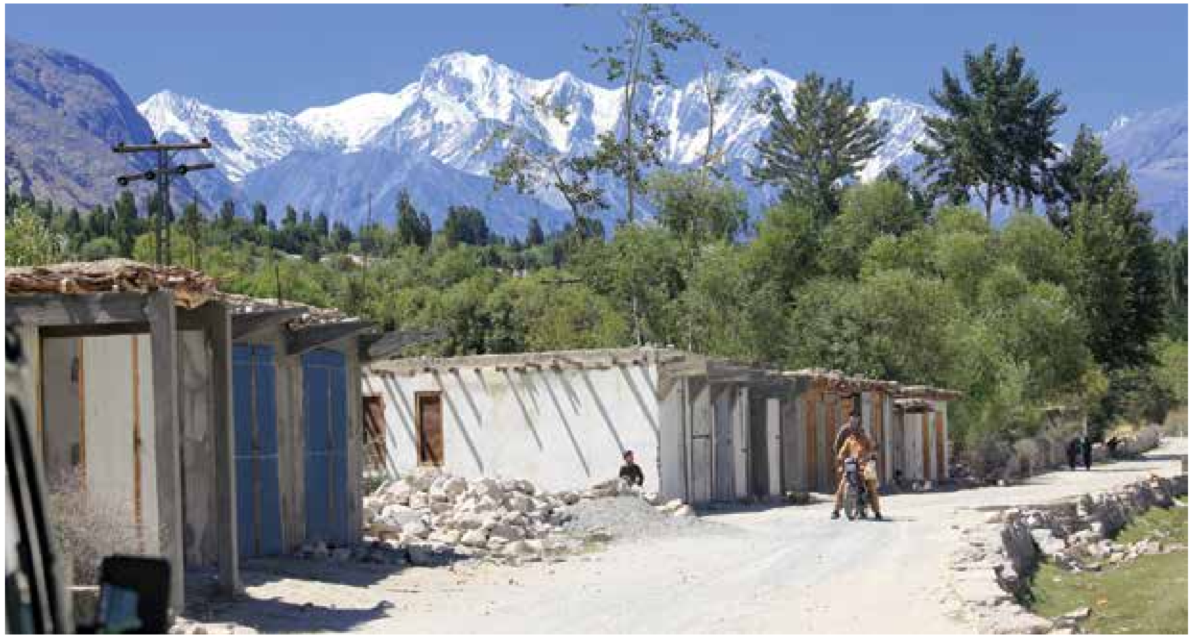
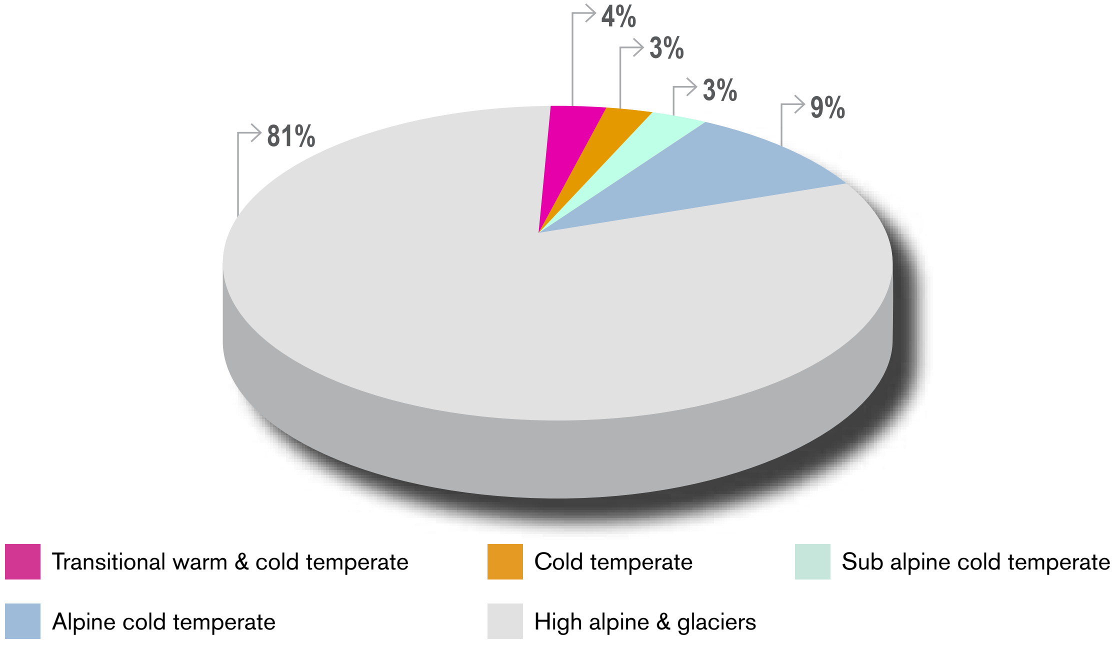


Figure 3. Percentage area under various AEZs

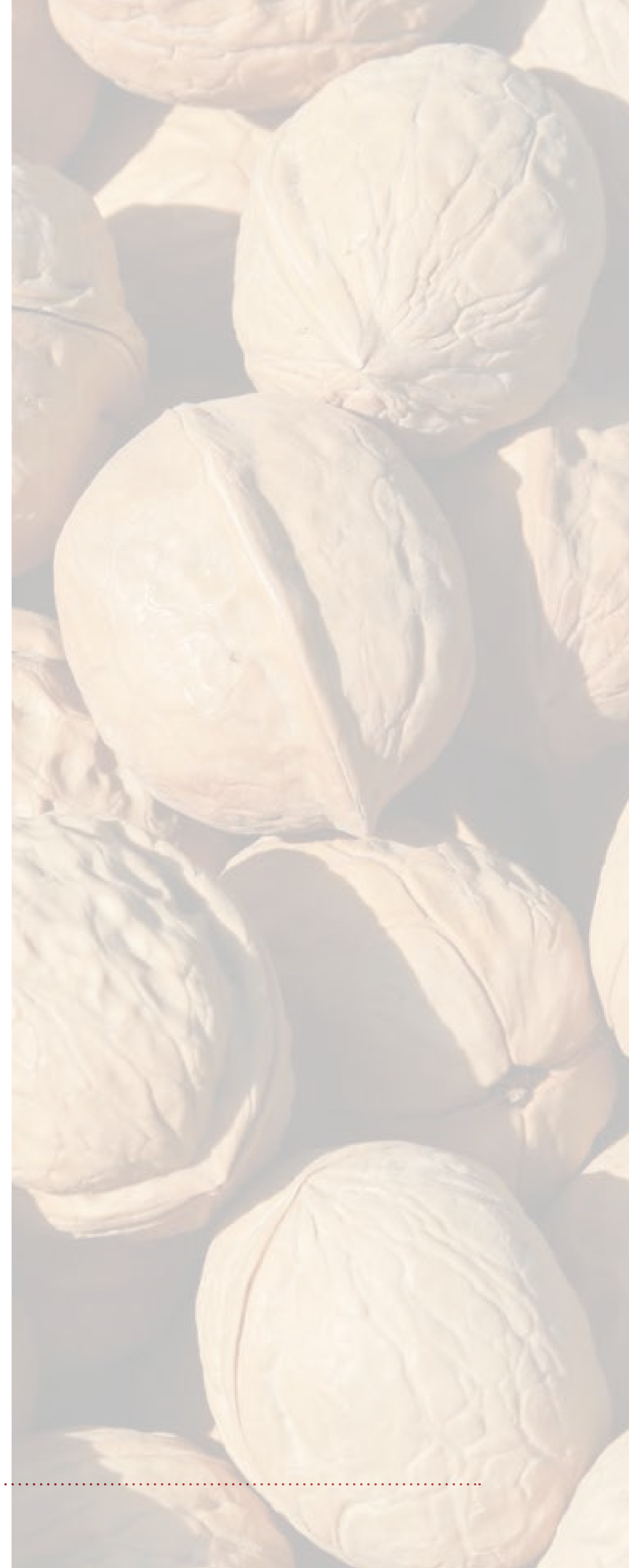


7. Agricultural potential

Shigar has a lot of untapped agricultural potential due to limited irrigation infrastructure. The district's lower areas are ideal for diverse vegetable production and traditional cereal and fruits. Shigar also has ideal isolated areas for production of cereal seed, seed potato and onion. In addition to introducing an appropriate cropping pattern, soil fertility management and erosion control are imperative in Shigar due to soil characteristics described earlier. The following specific crop potential has been identified in consultations with the Agriculture Department and the farming community as well as assessing the market potential and climatic suitability pertaining to various AEZs of the district (**Table 8**).

Table 8. Potential of crops in various AEZs

Type	Potential crops	Remarks
Potential in Transitional Warm & Cold Temperate zone		
Cereals	Wheat (winter sowing only), barley, buckwheat	Wheat, which is cultivated in spring must shift to winter. Interested farmers will need support in accessing appropriate seed. This will make limited agricultural lands available for other high value crops in summer. Among cereals for summer or later in autumn, barley followed by buckwheat may be a good choice. Alternatively, potato may be cultivated after wheat.
Vegetables	Potato, peas, tomato, onion, carrot, cabbage, red beans	Major vegetables in Shigar include cauliflower, carrot, cabbage, onion, tomato, cucumber, peas, and red beans. Farmers may decide to either grow winter wheat or leave the land fallow during winter for cultivating different vegetables or potato in the spring. Potato harvesting may follow short duration vegetables e.g., peas. red kidney beans may be cultivated on peripheries. Tomato and cucumber are strongly suggested to be cultivated in vertical farming tunnels for greater benefit. Intercropping with cabbage or Chinese cabbage may increase per unit area production and cash return.
Fruit	Apple, apricot, mulberry	Apple, apricot, and mulberry are niche fruits of Shigar with high economic gain. Other fruits include cherry, peach, almond, pears, and walnut. Shigar also qualifies for bulb production for floriculture. This potential may be further upscaled in this zone in Shigar.
Fodder	Barley / millet Alfalfa	Barley-millet for cereal and fodder Alfalfa intercropped with orchards
Potential in Cold Temperate zone		
Cereals	Barley, buckwheat	It is high recommended to discourage farmers for sowing spring wheat that occupy limited high value agricultural lands that may be better used for growing barley followed by buckwheat or Barley followed by vegetables for cash with peas or beans on the peripheries.
Vegetables	Potato, carrot, and broad beans	Potato is the most viable cash crop in this zone. Carrot, broad beans, peas, cabbage, and turnip may be short duration crops for cash and home consumption. Other vegetables may be grown for home consumption or local marketing such as cucumber, onion, chillies and tomato.
Fruit	Apricot and walnut	Apricot and walnut are significant in this zone. Other fruits include apple, mulberry, cherry, peach, almond and pear.
Fodder	Irrigated natural pastures and crop by-products	No specific cultivation
Potential in Sub Alpine Cold Temperate zone		
Cereals	Barley or buckwheat	Either barley or buckwheat may be cultivated in this zone due to short duration cultivation season
Vegetables	Potato, turnip, broad beans	Turnip and broad beans may be more suitable. Potato may be cultivated.
Fruit	Walnut and apricot	Walnut and apricot cultivation only for oil
Fodder	Natural pastures and crop by-products	No specific cultivation
Potential in Alpine Cold Temperate zone		
Cereals	None	The growing season in this zone is too short, and no cultivable / irrigated lands available in this zone in this district.
Vegetables	None	The growing season in this zone is too short, and no cultivable / irrigated lands available in this zone in this district.
Fruit	None	Not suited for fruits.
Fodder	Natural pastures and crop by-products	No specific cultivation




District Skardu
HUNZA
NAGAR
GHIZER
GILGIT
SHIGAR
GHANCHE
DIAMER
ASTORE
KHARMANG
SKARDU

Skardu

Latitude 35.3247° N and Longitude 75.5510° E

1. Introduction

District Skardu is spread over an area of 10,168 sq.km (1,016,800 Ha)[1], which is 14% of the total area of Gilgit Baltistan (GB). The district is bounded on the east by district Ghanche, on the south by district Kharmang, on the west by district Astore, on the north-west by district Gilgit and on the north by district Shigar. The district headquarter is the town of Skardu which is also the divisional headquarter of the Baltistan division of GB. The district is located at an average elevation of over 2,225 meters (m). The Deosai Plateau situated in the region is the second highest plateau in the world[2] after Qinghai-Tibet Plateau[3]. Deosai plateau has boundaries with districts Skardu, Astore and Kharmang. Administratively, Skardu is divided into four tehsils: Skardu, Gultari, Gamba and Rondu. The population of district in 2017 was 260,000 with 33,333 households at an average household size of 7.8[4] in 73 villages[5]. With a growth rate of 3.81[6], the estimated population of the district in 2022 is 313,451. This is the second highest population growth recorded in GB after Diamer. The overall literacy rate is 54% - 67% men and 41% women[7].

2. Land use statistics

According to the Agriculture Department GB, the total agricultural land of the district is 17,163 ha. Out of which 6,595.4 ha is cultivated whereas 10,567.6 ha is cultivable waste[8]. The land use statistics of district Skardu are given in **Table 1**.

Table 1. Land use statistics

S.No.	Type of Land	Area (Ha)	Percentage
1.	Agricultural Land	17,163	1.7%
2.	Forest Land	8,875	0.9%
3.	Range Land & Pastures	231,233	22.7%
4.	Rivers/Lakes	33,873	3.3%
5.	Built up Area	8,439	0.8%
6.	Snow/Glaciers	261,764	25.8%
7.	Rocks	392,461	38.6%
8.	Unaccounted for	62,991	6.2%
	Total	**1,016,800**	**100%**

Source: Calculated using GIS tools based on district shape files provided by GB Agriculture department 2022

3. Current features of agriculture

The crops grown and cropping pattern in Skardu is influenced by the elevation which ranges from about 2150 meters (m) to 3675 m. Double cropping is practiced below the elevation of 2450 m. Above this elevation, single cropping is practiced. Major cereal crops of the district include wheat, barley, maize, and buckwheat. The vegetables grown include potato, tomato, peas, cabbage, cucumber, turnip, carrot, radish, and beans. Major fruits include apricot, mulberry, apple, almond, walnut, cherry, grapes, pear, and peaches. It is important to note that farmers grow multiple crops for subsistence in the same season. The typical cropping pattern followed in Skardu is given in **Table 2**.

Table 2. Current cropping pattern

Altitude (m) and major locations (examples)	Current Cropping Pattern
Altitude: 2240 to 2440 **Cropping season:** February–September Marginally double cropping / single cropping at higher elevations **Major locations:** Lower Ganji, Shout, Dambodas and rest of Rondo, main Skardu, Qumrah	• Wheat followed by buckwheat – OR • Barley followed by buckwheat – OR • Barley followed by millet – OR • Barley followed by maize – OR • Barley followed by vegetables • Potato – fallow • Vegetable on small areas parallel to crop • Fodder as irrigated perineal crop on small scale • Fruits are extensively grown
Altitude: Above 2440 to 2745 **Cropping season:** March–September Single cropping **Major locations:** Hussainabad, Gole, Sermik, Lower Basho	• Wheat followed by fodder • Barley followed by millet – OR • Barley followed by buckwheat – OR • Barley followed by vegetables • Potato – fallow • Vegetable parallel to crops • Fodder as irrigated perineal crops • Fruits are extensively grown
Altitude: Above 2745 to 3050 **Cropping season:** April–September Single cropping **Major locations:** Chunda valley, Doro, Shilla, Sadpara, mid Basho	• Wheat – fallow OR • Barley followed by buckwheat – OR • Potato – fallow OR • Vegetable parallel to crops • Fodder as irrigated perennial crops • Few types of fruits are (apricot, mulberry
Altitude: Above 3050 **Cropping season:** May–August Single cropping **Major locations:** Gultari valley, Sultanabad Basho	• Wheat – fallow OR • Barley – fallow OR • Buckwheat – fallow OR • Potato – fallow OR • Vegetable parallel to crops • Fodder as irrigated perineal crops • Fruits are rare

Source: Primary data from district consultation workshops and interviews June 2022

[1] Gilgit Baltistan at a glance 2020. Government of Gilgit-Baltistan
[2] https://www.quora.com/Which-is-the-second-highest-plateau-in-the-world
[3] https://www.geographyrealm.com/largest-plateau-in-the-world/
[4] Gilgit Baltistan at a glance 2020. Government of Gilgit-Baltistan
[5] Agriculture Statistics 2014. Gilgit Baltistan
[6] https://www.citypopulation.de/en/pakistan/cities/gilgitbaltistan
[7] Gilgit Baltistan at a glance 2020. Government of Gilgit-Baltistan
[8] Agriculture Census 2020, department of Agriculture Gilgit Baltistan

4. Soil characteristics

Skardu has three soil types of which Lithosols are dominant followed by Eutric Cambisols and few patches of Gleysols. Lithomorphic soils are thin (less than 30cm deep) with slowly weathering coarse textured parent material, highly prone to land degradation and erosion. Sustainable crop production is a challenge on these soils since these soils need a lot of care and conservation measures. More attention is required for its conservation. If this shallow soil is lost, it will be a long weathering process before new soil is formed. These soils are evenly distributed in Skardu in tehils Rondu and Gultari. In the middle of the two stretches of Lithomorphic soils, a significant patch of Eutric Cambisol is located in tehsil Skardu of the district which is stretched towards Shigar and Kharmang districts. This is where most of the agriculture is practiced. Cambisols are among the most productive soils on earth. It is an opportunity for Skardu to have these soils just at the right altitudes with four significant agro-ecological zones explained in later sections. A few scattered small patches of Gley soils are located along district borders of Astore, Shigar and Kharmang. Most of these patches do not support agricultural activity since these are located on higher altitudes in high alpine and glacial zone.

Silty clay loam is a prominent soil texture found in Skardu followed by sandy loam. Organic matter is relatively marginal, and the pH is generally neutral to slightly alkaline. Areas adjoining Ghanche have a slightly acidic to neutral pH. **Table 3** summarises soil characteristics for Skardu.

Table 3. Summary of soil characteristics

Parent material	Organic Matter (%)	Fertility			Soil texture			pH
		NO3-N (mg kg^{-1})	P (mg kg^{-1})	K (mg kg^{-1})				
Lithosols 50% Cambisols 40% Gleysols 10%	Marginal	Low	Low	Low	Silty clay loam 65%	Sandy loam 21%	Silt loam 9%	Neutral to slightly alkaline. Slightly acidic to neutral in areas adjoining Ghanche

5. Climate trends

Skardu is warming and its temperatures are increasing in all the seasons. The most significant increase is noted in the spring season. The major increase is noted in the past 30 years. The average day time temperature has increased to 7.5°C from 6.85°C since 1991. The average night temperature has increased from -4.4°C to -3.3°C since 1991. The nights are becoming warmer in all the months at a faster rate than the days. The biggest increase is noted during the spring months.

Overall precipitation slightly increased between 1960-1990 during winter and summer months. However, during the last three decades, the precipitation is declining during winters, spring, and summers with a slight increase during Autumn.

Following sub sections provide details on day and night temperatures (**Tables 4 and 5**), and precipitation (**Table 6**). The analysis in these sections is based on average conditions. There may be year to year variations (e.g., cold wave during spring, or wetter than average or drier than average). This climate variability is not accounted for in ascertaining climate change trend.

5.1 Analysis of maximum temperature

- Mean monthly day time temperature during winter months is increasing. Major change is recorded in the months of January and February. December temperature has increased with respect to 1960 but is declining since 1991.
- Day temperatures in spring are increasing at the fastest rate among all seasons. The biggest increase is recorded in the months of March and April (1.9°C) since 1991. This shows setting early spring and early summers.
- Daytime temperatures in summers have increased since 1991 to varying degrees with maximum increase recorded in July and September.
- Day temperatures in autumn are increasing for October since 1960. Temperate in November was earlier increasing between 1960-1990 but it is now showing slightly declining trend since 1991. However autumn has also become warmer since 1960.

Table 4. Trend analysis of mean monthly maximum temperature (°C)

	1960-2020			1960-1990			1991-2020		
Months	Change from – to	Change in temperature	Trend	Change from – to	Change in temperature	Trend	Change from - to	Change in temperature	Trend
Dec	-3.1 to -2.4	0.7	↑	-3.2 to -2.6	0.6	↑	-2.4 to -2.8	-0.4	↓
Jan	-5.9 to -5.9	0	↔	-6.2 to -5.4	0.8	↑	-6.4 to -5.7	0.7	↑
Feb	-4.9 to -3.7	1.2	↑	-4.7 to -4.7	0	↔	-4.1 to -3.8	0.3	↑
Mar	0.6 to 2	1.4	↑	1.5 to 0.3	-1.2	↓	0.8 to 2.7	1.9	↑
Apr	6.2 to 7.8	1.6	↑	6.3 to 7	0.7	↑	6.4 to 8.3	1.9	↑
May	9.8 to 10.9	1.1	↑	9.7 to 10.5	0.8	↑	10.1 to 11.1	1	↑
Jun	15.2 to 14.6	-0.6	↓	15.4 to 14.6	-0.8	↓	14.8 to 15	0.2	↑
Jul	18.4 to 18.4	0	↔	18.5 to 18.3	-0.2	↓	18.1 to 18.6	0.5	↑
Aug	17.9 to 17.6	-0.3	↓	18 to 17.8	-0.2	↓	17.6 to 17.8	0.2	↑
Sep	15.1 to 15.2	0.1	↑	15 to 15.4	0.4	↑	14.8 to 15.3	0.5	↑
Oct	9.2 to 9.8	0.6	↑	9.5 to 9.1	-0.4	↓	9 to 10.3	1.3	↑
Nov	2.5 to 3.7	1.2	↑	2.2 to 3.3	1.1	↑	3.5 to 3.3	-0.2	↓

5.2 Analysis of minimum temperature

- Mean monthly night temperatures during winter months show an increasing trend during the last 60 years (1.2°C and 1.7°C). The night temperatures for December are showing a slightly declining trend since 1991, although these were also increasing between 1960-1990.
- Night temperatures in spring are increasing more when compared to other seasons.
- Summer nights are also becoming warmer. Temperatures are increasing more at night than days. Maximum change is observed in the months of August and September
- Warming trend is also observed in autumn with the highest increase in October. Autumn is becoming milder.

Table 5. Trend analysis of mean monthly minimum temperature (°C)

	1960-2020			1960-1990			1991-2020		
Months	Change from – to	Change in temperature	Trend	Change from – to	Change in temperature	Trend	Change from – to	Change in temperature	Trend
Dec	-13 to -11.3	1.7	↑	-13.4 to -11.8	1.6	↑	-11.6 to -11.8	-0.2	↓
Jan	-15.6 to -14.4	1.2	↑	-15.9 to -14.4	1.5	↑	-15 to -14.4	0.6	↑
Feb	-14.4 to -13	1.4	↑	-14 to -14.4	-0.4	↓	-13.6 to -12.9	0.7	↑
Mar	-9.4 to -7.5	1.9	↑	-8.9 to -9.1	-0.2	↓	-8.9 to -7	1.9	↑
Apr	-4.8 to -2.7	2.1	↑	-4.5 to -3.9	0.6	↑	-4.5 to -2	2.5	↑
May	-2.4 to -0.1	2.3	↑	-2.2 to -1.4	0.8	↑	-1.5 to 0.2	1.3	↑
Jun	2.6 to 3.5	0.9	↑	3.2 to 2.5	-0.7	↓	2.7 to 3.9	1.2	↑
Jul	5.7 to 6.8	1.1	↑	6.2 to 5.8	-0.4	↓	5.8 to 7.2	1.4	↑
Aug	5.4 to 6.4	2	↑	5.7 to 5.5	-0.2	↓	5.3 to 7	1.7	↑
Sep	1.2 to 2.5	1.3	↑	1.7 to 1.3	-0.4	↓	1.3 to 3	1.7	↑
Oct	-4.4 to -2.5	1.9	↑	-3.7 to -4.1	-0.4	↓	-4.3 to -1.7	2.6	↑
Nov	-9.4 to -7.9	1.5	↑	-9.4 to -8.6	0.8	↑	-8.9 to -7.7	1.2	↑

5.3 Analysis of precipitation

- In winter, precipitation has increased from 1960 but a negative trend is noted during the last 30 years.
- A negative trend in precipitation is also observed in spring season.
- In summers, precipitation has overall increased since 1960. This increasing trend has, however, started slowing down since 1991.
- Overall, autumn precipitation has slightly reduced since 1960 but the trend observed during the last 30 years show a slight increase.

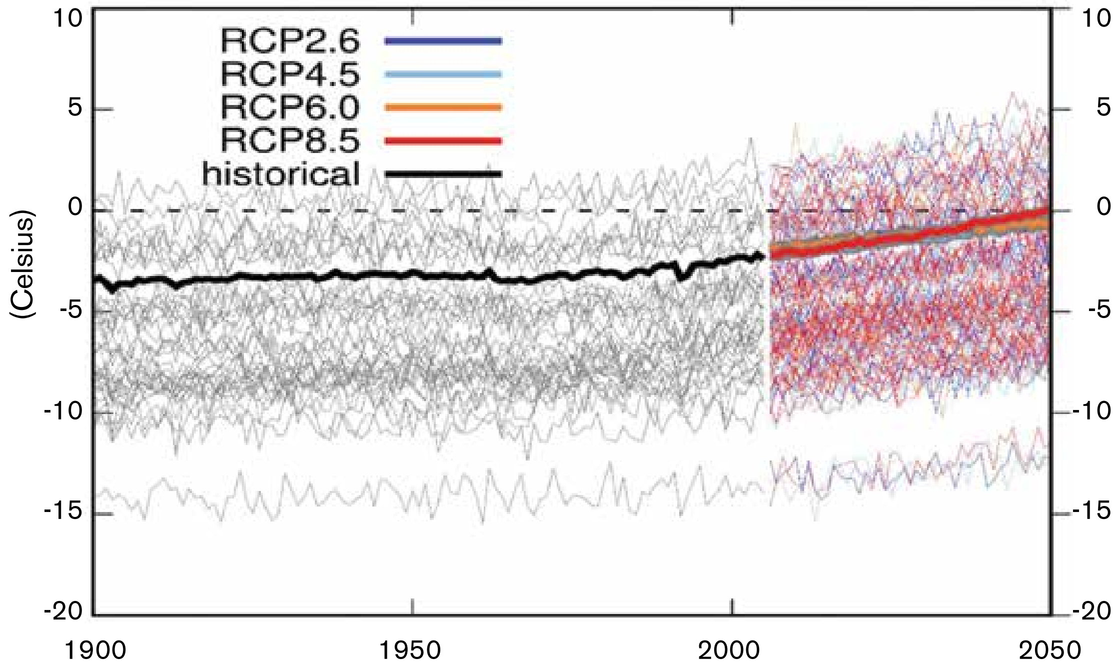
Table 6. Trend analysis of annual and seasonal precipitation (mm)

	1960-2020			1960-1990			1991-2020		
Season	Change from - to	Change in precipitation	Trend	Change from - to	Change in precipitation	Trend	Change from - to	Change in precipitation	Trend
Annual	379 to 408	29	↑	356 to 421	65	↑	405 to 393	-12	↓
Winter	91 to 107	16	↑	85 to 105	29	↑	105 to 102	-3	↓
Spring	150 to 136	-14	↓	148 to 145	-3	↓	145 to 134	-11	↓
Summer	105 to 136	31	↑	96 to 130	34	↑	131 to 126	-5	↓
Autumn	33 to 29	-4	↓	27 to 41	14	↑	24 to 31	7	↑

5.4 Climate scenarios

The following time series is based on near surface temperature with projections till 2050 based on different emissions scenarios (as explained in the methodology) and how these emissions may affect the temperature change in Skardu. Taking the historical trend from 1900, **Figure 1** projects near surface temperature of Skardu increasing from around -3.5°C in 1900 to around -1°C and 0°C by 2050 depending how the world tackles GHGs emissions.

Figure 1. Temperature projection till 2050



Source: IPCC Assessment Report 5 – 2014

The impact of climate change includes the following:

- The warmer spring season in Skardu provides an opportunity for early sowing of crops.
- On the other hand, the warmer spring temperatures may not allow the snow to consolidate longer and can trigger early snowmelt, resulting in availability of more water in spring season but also flash floods.
- Due to higher temperatures in September and October, warmer weather is extending into autumn. As a result autumn will start later and get milder. Warmer spring and autumn seasons are expanding the crop growing season and providing opportunity to convert some of the areas into double cropping zones.

6. Agro-ecological zones

Skardu district comprises of five Agro-ecological zones (AEZs). **Figure 2** shows AEZs whereas **Figure 3** shows percentage area of the district falling under various AEZs. Names of zones and major locations falling in each zone are given in **Table 7.**

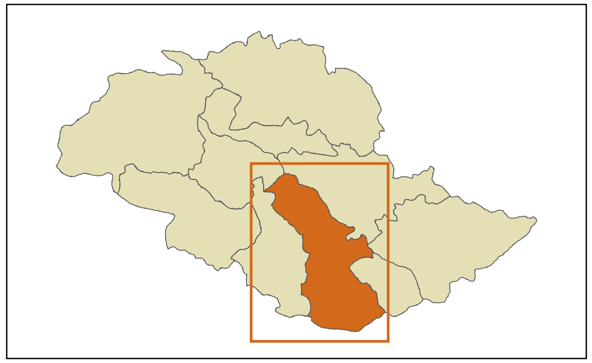


Figure 2. Agroecological zones of Skardu District

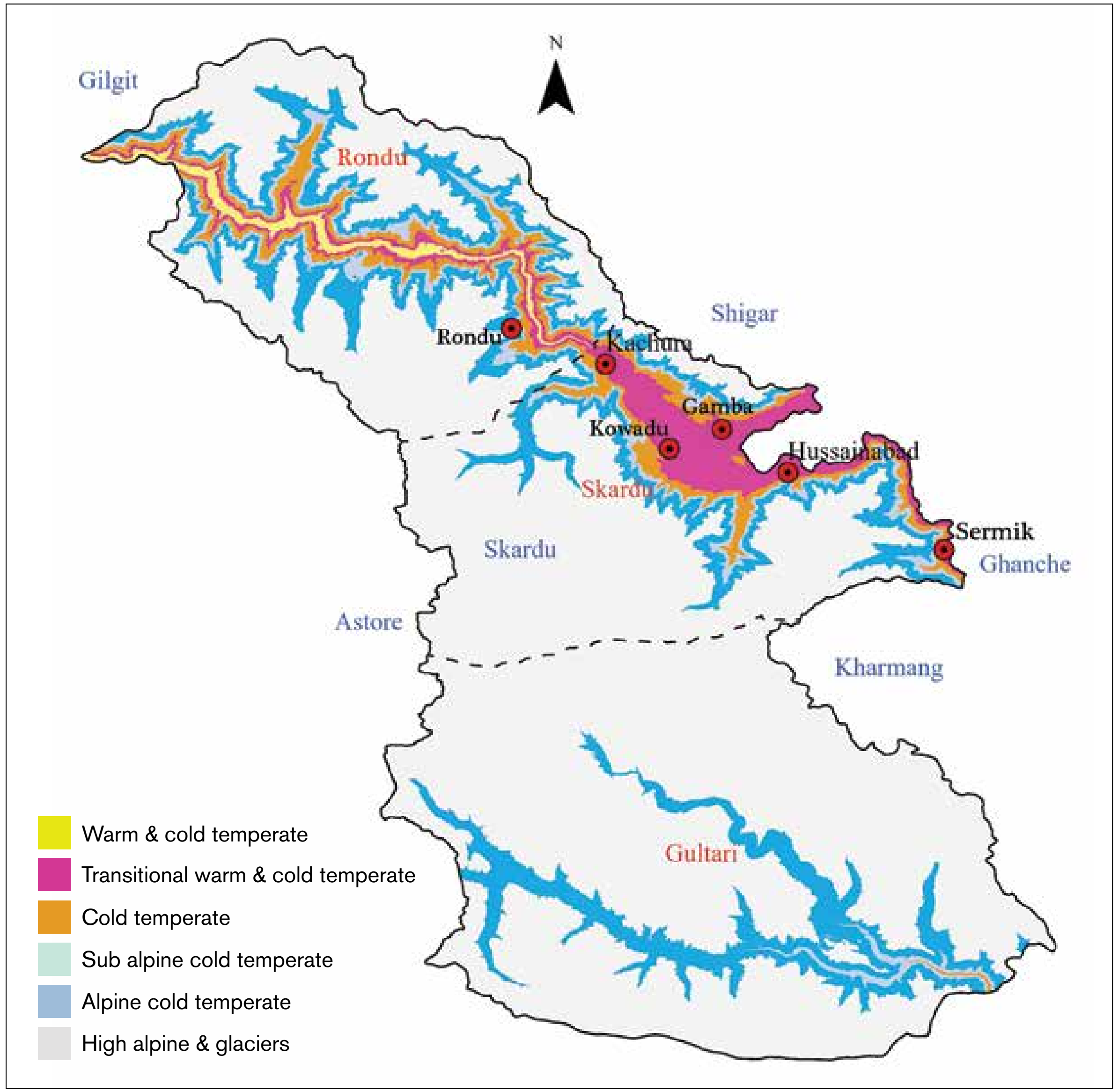
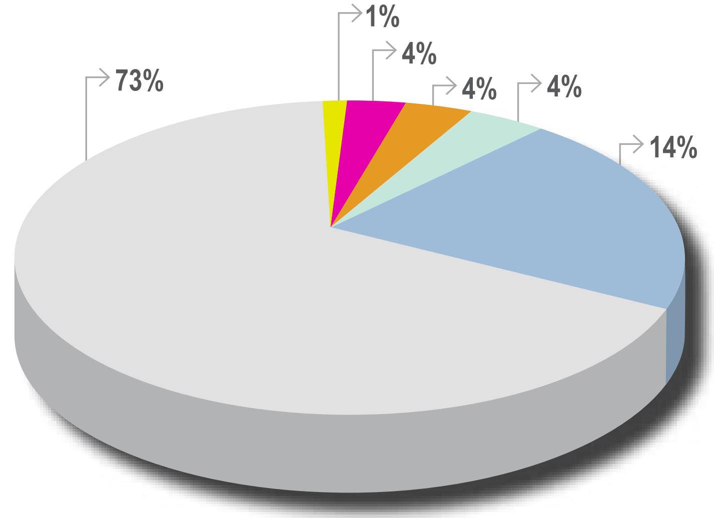


Table 7. Major locations falling in various AEZs

Agro-ecological zones	Major locations
Warm & Cold Temperate Elevation: 5,500 – 7,000 feet (1,720 – 2,150 m) Avg. Temp.: 4.4°C Avg. Precipitation: 389 mm	This zone falls in limited pockets of Rondu tehsil district Skardu. Major locations include Basho lower, Sundas, Qumrah, Katpana, Gamba, Gol, Shangus, Chamachu, Ganji, Talu, Dambodas, Shot, Kushmal
Transitional Warm & Cold Temperate Elevation: 7,000 – 8,000 feet (2,150 – 2,450 m) Avg. Temp.: 3.9°C Avg. Precipitation: 419 mm	This zone is mainly located in Skardu tehsil, followed by Rondu and at a limited scale in Gultari tehsil. This zone is fast turning into double cropping system. Major areas include Hussainabad, Bilamik, Talubrok, Stak, Tormik, Khomer, Hengu, Hardas, and Upper Kachora
Cold Temperate Elevation: 8,000 – 9,500 feet (2,450 – 2,900 m) Avg. Temp.: 3.2°C Avg. Precipitation: 441 mm	This zone is equally represented in Rondu and Skardu tehsils. Major areas include higher reaches of Hussainabad, upper Bilamik, upper Talubrok, upper Stak, upper Tormik, Khomer, Hengu, Hardas and Upper Kachora.
Sub Alpine Cold Temperate Elevation: 9,500 – 10,500 feet (2,900 – 3,200 m) Avg. Temp.: -3.5°C Avg. Precipitation: 339 mm	This zone is located in Gultari, Rondu and Skardu tehsils. The areas include Gultari (Chaqma, Bunial, Phultukus), Nazimabad Basho.
Alpine Cold Temperate Elevation: 10,500 – 12,500 feet (3,200 – 3,800 m) Avg. Temp.: -4.0 °C Avg. Precipitation: 259 mm	This is the largest agro-ecological zone that is prevalent in all the tehsils at higher altitudes. Locations include Upper Gultari (Shingo Shigar, Nowgam, Gultari proper, Matial, Ganial), Shilla, Dappa, Sultanabad Basho.
High Alpine and Glaciers Elevation: 12,500 feet + (3,800 m +) Avg. Temp.: -7.1°C Avg. Precipitation: 227 mm	12,500 feet / 3,800 above sea level and higher. This is an aera which is only used as high-altitude pastures and not for crops.

Figure 3. Percentage area under various AEZs

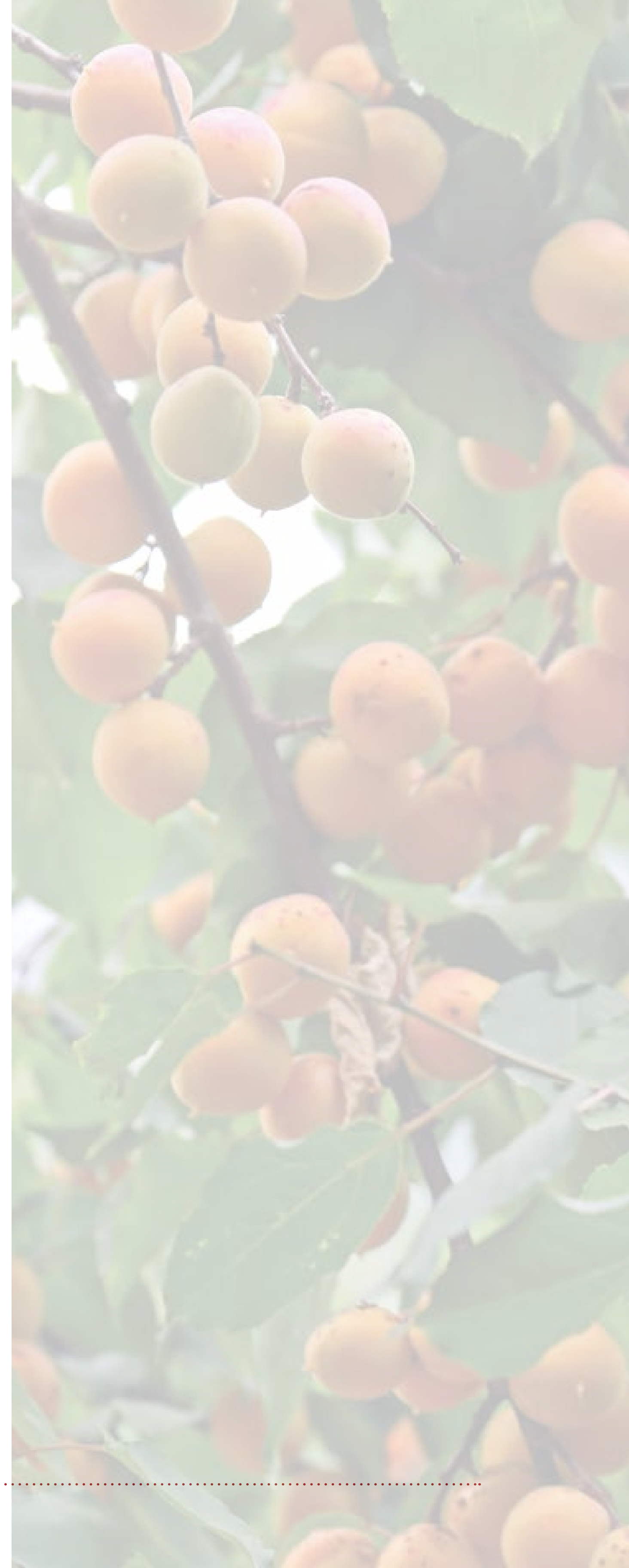


Warm & cold temperate | Transitional warm & cold temperate | Cold temperate
Sub alpine cold temperate | Alpine cold temperate | High alpine & glaciers

7. Agricultural potential

In an irrigated agriculture system, most crops may be grown in most of the zones except for the Alpine Cold Temperate zone where fruits and wheat do not ripe due to short growing season. However, some crops grow well in some zones compared to others. The recommendations therefore are based on what could grow well giving best yields, and not on which crops are grown at present. Skardu is an ideal zone for certified seed production. There's a high potential for seed production in Rondu Tehsil. Onion seed production is suitable in transitional zone, but it is essential to find necessary isolation for air pollinated seed crop. Similarly seed production of okra, garlic and carrot are favourable in this zone. In addition to introducing an appropriate cropping pattern, soil fertility management and erosion control are imperative in Skardu due to soil characteristics described earlier. The following specific crop potential has been identified after data analysis and in consultations with the Agriculture Department and the farming community as well as assessing the market potential pertaining to various AEZs of the district (**Table 8**).

Table 8. Potential of crops in various AEZs



Type	Potential crops	Remarks
Potential in Warm & Cold Temperate zone		
Cereals[9]	First priority Maize Wheat (winter sowing), Barley	Winter wheat followed by Maize in summer is the first priority in this zone for subsistence and to contribute to self-sufficiency in grain. Cultivation of wheat is summer is not recommended. Farmers reported that seed for winter wheat is a challenge and needs to be arranged on timely basis in Skardu. Quinoa may be cultivated on the peripheries of maize to acquire grain without sacrificing land for maize cultivation. Quinoa is an emerging cash crop as a superfood and has been successfully experimented in Basho valley.
Vegetables	Potato, okra, tomato, chilies, cauliflower, cabbage, onion, cucumber, bottle gourd, spinach	In warm and cold zone of Skardu, potato is sown earlier and, therefore, the production arrives earlier, which receives comparative advantage in the market due to early crop. Similarly, cabbage and cauliflower produced in this zone can compete with the products coming from other regions including Swat in Khyber Pakhtunkhwa. Tomato and cucumber are strongly suggested to be cultivated in vertical farming tunnels for greater benefit. Tomato in this zone has a seasonal advantage (early production when tomato is short in the rest of Pakistan in August-October), intercropping with cabbage or Chinese cabbage may increase per unit area production and cash return. Onion performs well in Rondu including for seed production.
Fruit	Apricot, apple, cherry, grapes, peach, almond, mulberry, pear, walnut	Top priority fruits in this zone are apricot followed by apples and peers. Fresh apricot, kernels and oil are promising products and may be further developed. Blackcurrant is well placed here since unlike other areas, this fruit is relatively less exposed to the issue of powdery mildew. Walnut has a high market potential industry. Almond is another high potential fruit for marketing.
Fodder	Trifolium / Shaftal / Berseem Alfalfa	Cultivated separately as well as intercropped with orchards and maize.
Potential in Transitional Warm & Cold Temperate zone		
Cereals[10]	Wheat (winter sowing only), Maize, buckwheat, barley, Quinoa	Wheat, which is cultivated in spring in this zone, must shift to winter. Interested farmers will need support in accessing right seed. This will make limited agricultural lands available for other high value crops in summer. Among cereals for summer or later in autumn, Maize followed by buckwheat may be a good choice. Winter wheat may be followed by maize, or barley-buckwheat and/or vegetables. Alternatively, potato may be cultivated after wheat. Quinoa may optimally be grown on the peripheries along buckwheat or maize. Quinoa is an emerging cash crop as a superfood and has already been tried successfully in the villages from Basho valley falling in this zone.
Vegetables	Potato, peas, tomato, reddish, carrot, chilies, turnip	Farmers may decide to either grow winter wheat or leave the land fallow during winter for cultivating potato in the spring. Potato harvesting may follow short duration vegetables e.g., peas. Alternatively, barley-buckwheat may be cultivated after harvesting wheat. Tomato and cucumber are strongly suggested to be cultivated in vertical farming tunnels for greater benefit. Intercropping with cabbage or Chinese cabbage may increase per unit area production and cash return. Red kidney beans may be cultivated on peripheries or intercropped with maize. Cauliflower and cabbage have seasonal advantage from this zone in Skardu over production from Swat / KP.

[9]Barley is cultivated for subsistence (also for fodder) in few areas in this zone as a cover crop between wheat harvesting and maize sowing. However, not recommended for upscaling since it competes for land against high value vegetables.

[10]Barley-millet are cultivated as two short crops to cover for cereal and fodder requirements in this zone. This may be replaced by maize or barley-buckwheat to cover for fodder as well as cash.

Fruit	Apricot, apple, cherry, grapes, walnut	Cherry has a seasonal advantage in transitional zone of Skardu since the crop arrives after cherry from Gilgit have reached market. Apricot flourishes in this zone and merits high attention to preserve fruit losses and turn this into economic potential.
Fodder	Barley / millet Alfalfa	Barley-millet for cereal and fodder Alfalfa intercropped with orchards and maize
Potential in Cold Temperate zone		
Cereals	Barley, buckwheat	It is high recommended to discourage farmers from sowing spring wheat or maize that occupy limited high value agricultural lands that may be better used for growing Barley followed by Buckwheat or Barley followed by vegetables for cash with peas or beans on the peripheries.
Vegetables	Potato, peas, turnip	Potato is the most viable cash crop in this zone. Peas and turnip may be short duration crops for cash and home consumption.
Fruit	Apricot, apple, cherry	Apricot and apple continue to be significant in this zone, followed by cherry.
Fodder	Irrigated natural pastures and crop by-products	No specific cultivation
Potential in Sub Alpine Cold Temperate zone		
Cereals	Barley	Traditionally, farmers in this zone cultivate barley for self-consumption and it is highly suitable in this zone.
Vegetables	Potato, peas, turnip	Potato is the only and most viable cash crop in this zone. Cultivation of turnip is suited due to high local demand. Peas may be cultivated as short duration crop for cash or self-consumption.
Fruit	None	This zone is not fit for fruit crops. Walnut and apricot may be cultivated to produce kernels for oil extraction.
Fodder	Natural pastures and crop by-products	No specific cultivation
Potential in Alpine Cold Temperate zone		
Cereals	Barley	The growing season in this zone is barely enough for short duration crops of barley.
Vegetables	Potato, turnips	Potato remains a cash crop in this zone, although more suited for local consumption due to remoteness from the market. Cultivation of turnip is also favoured mainly for supporting local consumption.
Fruit	None	Not suited for fruit trees.
Fodder	Natural pastures and crop by-products	No specific cultivation

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