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CERG 2006

"Hazard & Vulnerability Assessment of Sherqila Village

District Ghizer NAs Pakistan"

by

Ejaz KARIM

In association with:

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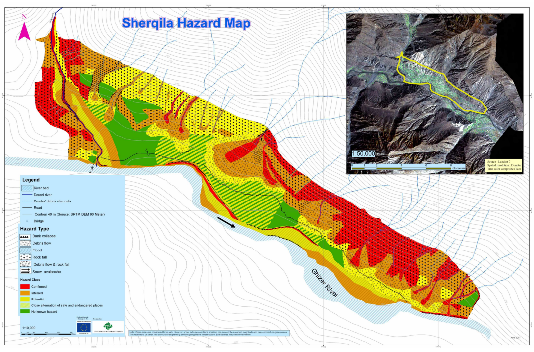
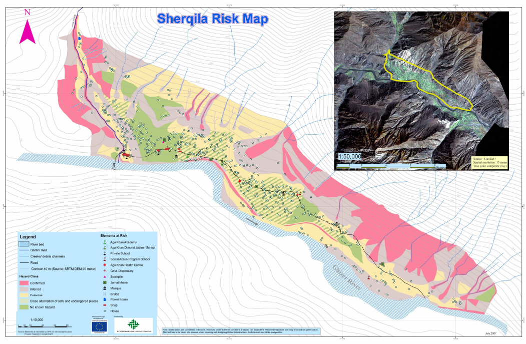
Hazard & Vulnerability Assessment of Sherqila Village

District Ghizer NAs Pakistan

With special emphasis on

Hazard and Risk Mapping





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By

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I am extending my deepest gratitude to Swiss Development Cooperation (SDC) for their generous financial support to attend the CERG course with out their aid it was impossible for me to reach at this stage of professional caliber.

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Summary

Pakistan’s Northern Areas are located within the highest mountains of the world. The Himalaya, Karakoram and Hindukush ranges consist of very high mountain peaks, covered by snow, ice, and deeply intersected valleys where towns and villages are stringed like pearls of a necklace. For many centuries, the population lived on subsistence. Water is the limiting factor for agricultural activity as the whole area is semi-arid to arid. In addition to farming as livelihood, international trade routes passed the main valleys (e.g. part of the famous silk route). In recent decades, the mountainous scenery and some of the highest mountains attracted tourists from all over the world.

The steep relief, snow and glaciers, rare but strong precipitation and a high seismicity constitute the basis for widespread natural processes like debris flows, floods, earthquakes, rock fall or landslides. Of particular importance are flash floods triggered by the outburst of lakes in very remote places. Many of these hazards are directly threatening people’s life and livelihood: Natural disasters are a common phenomenon. Every year people, their livelihoods and assets are badly affected. Desperately needed means for development are again and again deviated to emergency relief and rehabilitation.

Despite the ubiquitous presence of natural hazards, the knowledge about these processes is limited. Whereas the awareness for so-called local hazards (processes which have their origin near the place of impact) exists at least partially, the remote hazards (processes which have their origin far away from the impact zone) are almost unknown.

Specific to such multiple hazards there is lack of expertise inside the country that could assess theses processes and forecast the probability of occurrence and warned the communities regarding possible sever impact and losses.

Author as a geologist and dealing with such natural processes and disaster management activities of FOCUS Pakistan realized that CERG” course is a best fit and an ideal opportunity to strengthen the in-house capacity in order to deal with these natural phenomenon. The entire course period of two and half months comprised of extensive field work and class work enabled me in a professional way to assess the situation critically and forecast the future probability of occurrence of such hydro-meteorological processes.

This research project (Hazard, Vulnerability, and Risk Assessment) of the particular village Sherqila contributes to provide an idea and guideline regarding risks and hazards. It endeavours to provide the necessary instruments to integrate disaster risk information into sustainable development, land-use planning at village level and to have tools ready for the emergency planning.

As such, the project contributes directly to the 2nd priority for action of the HFA (Hyogo Framework for Action) and indirectly to the 4th and 5th priority.

The project concentrated its activities in Sherqila village of Punial tehsil (Ghizer district, Northern Areas of Pakistan.

The aims of the project are as follows;

- to provide information about remote hazards in the watershed of Ghizer River (12,000 km^2) possibly affecting village

- to provide information about local hazards in the inhabited area of Sherqila village
- disseminate hazard and risk information to stakeholders in the area and to make them familiar about the natural hazards which surrounds their environment.

Considering the aims listed above and taking into account the difficulty for the dissemination of risk information to local stakeholders and the population at three types of products have been developed which can transport this information in an easy and readable way:

1. Overview maps for Ghizer River remote hazards (existing lakes which can break out, potentially lake formation on glaciers and potential valley blockages where lakes can form behind). In addition, the overall earthquake information is provided (fault lines, past events).
2. Hazard map of Sherqila village in a scale:1:10,000 The map give information about the prevailing process (debris flow, flood, rock fall, bank collapse, snow avalanche etc.) and the probability of occurrence. This degree of danger is represented by the colours of the traffic light:
   - red: high danger (about 1 to 10 years recurrence interval)
   - orange: moderate danger (about 10 to 30 years recurrence interval
   - yellow: low danger (about 30 to 100 years recurrence interval)
   - green: no know hazard. The area is considered to be relatively safe
3. Risk maps for the same village and respective scale. This is simplified risk maps, showing vulnerable elements overlaid on the main hazard classes.

The hazard and risk assessments revealed the following:

- Despite the steep relief and the mountainous conditions the Punial tehsil is relatively stable. However the village is on alluvial and debris fans. It is occasionally affected by floods and flows and other processes. Nevertheless, there are many locations which are suitable for living and livelihood, but the relatively safe space is limited. At present the development of village is growing into less suitable areas. A fast rise of vulnerability can be observed.
- Climate change is a major issue for the whole area. Conditions that are more humid will have an unfavourable impact on the stability of slopes. More rock fall or debris flows have to be assumed.
- The catastrophic outburst of lakes (dammed by glaciers, moraines or major landslides) has to be taken into account in both investigated regions; however, the relevance in at Sherqila in Punial is much bigger.
- Earthquakes have to be expected everywhere and anytime, even if no major event occurred in the recent past.
- In many locations, the local population is at risk. In particular, recently erected sensitive infrastructure (schools, hospitals, prayer facilities and others) are at risk from moderate or even high danger. This trend has to be curbed. In addition, recent housing development in the rapidly growing main village is occupying unsuitable places. These places are likely to be affected by natural processes. Therefore, the integration of hazards into local land-use planning is urgently required. The emergency services need

not only to consider local hazards with limited spatial impact, but should foresee the catastrophic drainage of lakes which would cause the whole area to be cut-off from the main roads for weeks or even months.

- It turned out that hazard and risk map in a scale 1:10,000 are the most appropriate to represent the degree of hazard and the most elements at highest risk.

Acronyms

FOCUS: it is not an abbreviation. It is the short name of FOCUS Humanitarian Assistance Pakistan

FHAP: FOCUS Humanitarian Assistance Pakistan

CBDRM: Community Based Disaster Risk Management

CERTs Community Emergency Response Teams

VERTs Village Emergency Response Teams

HVRA: Hazard Vulnerability risk Assessment

AKDN: Aga Khan Development Network

FANA: Federally Administrated Northern Areas

Nala: Local name used for drainages (both dry & wet)

GLOF Glacier Lake Outburst Flood

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1 Background

1.1 The Northern Areas: main risks

Risks from geological and hydro-meteorological hazards are a major issue for people's life and livelihood in Pakistan's Northern Areas. The entire region is located in a seismically active zone and similarly these mountain valleys are prone to hydro-meteorological hazards like landslides, rock fall, debris flow, snow or ice avalanches, glacial lake outburst floods (GLOF), flooding and erosion.

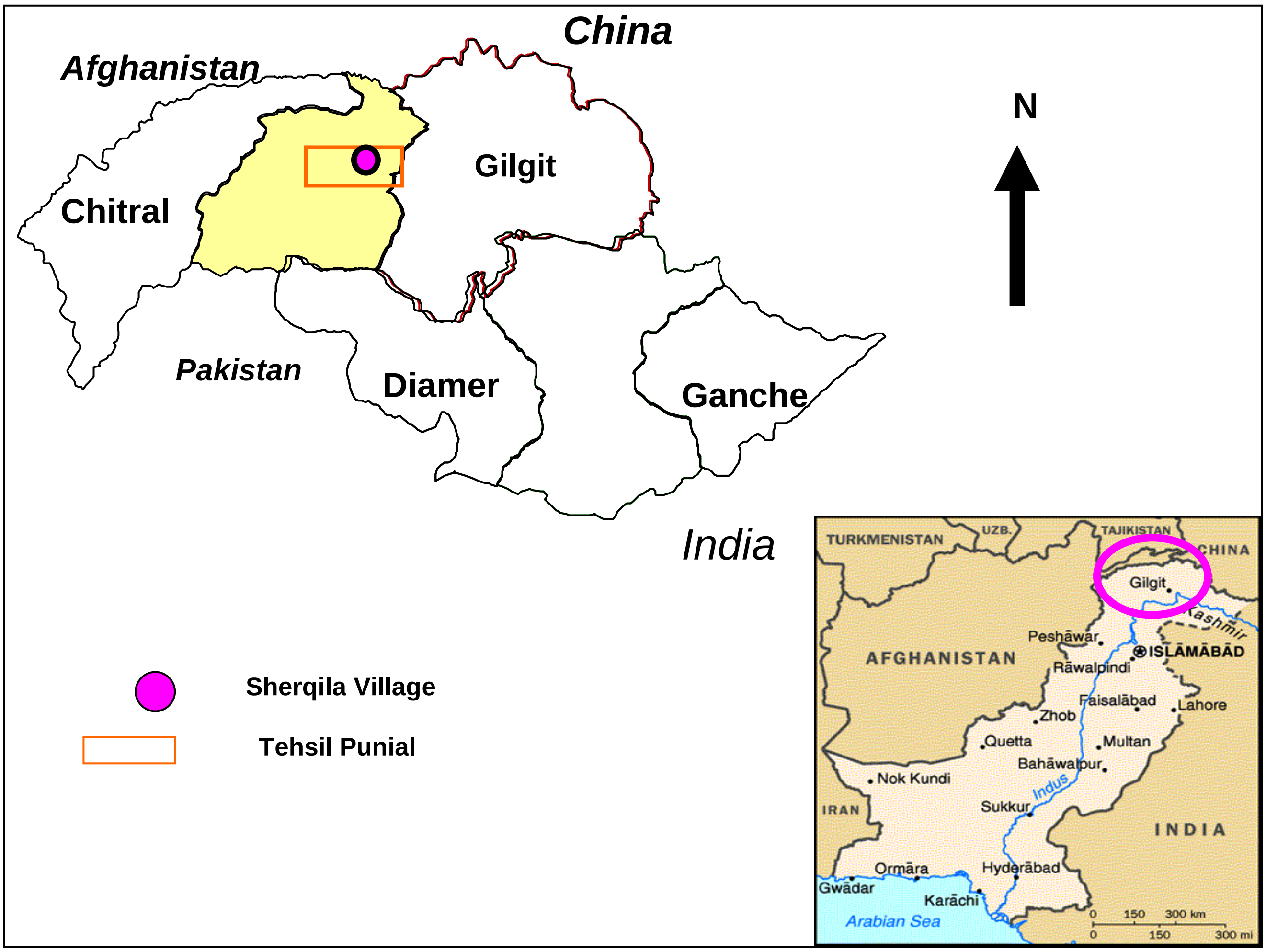
Earthquakes, floods or debris flows frequently disrupt normal life and regularly constitute a setback in the development of the area. Beside the "normal" natural events which occur frequently and have limited geographical extent, a number of past historic (catastrophic) events like the 1893 and 1905 Karambar Glacier lake outburst floods, or the 1858 Sarat rock avalanche with subsequent catastrophic lake outburst flood occurred in Northern Areas and destroyed numerous villages along the main rivers downstream (Kreutzmann, 2006; p. 253)

The local population is heavily exposed to these natural phenomena. In addition, there is an increase in physical vulnerability as new areas are used for housing, business and agriculture which are at risk from natural hazards, and therefore, not suitable for any type of human activity. Beside the population's exposure to natural threats the socio-economic conditions in Northern Areas are unfavourable.

Poverty is a major issue in the area, *(<1 dollar per day) appear to be alarmingly high, at 59 per cent, not to mention an even worse situation in other parts of the Northern Areas"* (Malik and Piracha, 2006, p. 367). Most families have limited resources and few livelihood options. Their capacities to cope with the risks from multiple hazards are almost negligible. In addition, according to IUCN Pakistan the high population growth rate (5 to 6 children per family are still normal) lead to a considerable increase in the demand for food, energy and land requirements. Few developing organization and government line agencies are investing in the living standards of the households.

An important issue in the whole area are indications for an unfavourable effect of climate change on nature and natural hazards (cf. Archer 2001). People notice changes in snow fall (stronger events with subsequent avalanches), more frequent thunder storms as well as an earlier start of the hot and dry season.

Fig: 1 Northern Areas and Chitral (Pakistan)



1.2 *Disaster risk reduction in the area*

The prevailing risks in Northern Areas would obviously demand the systematic integration of disaster risk issues into humanitarian and development planning. As an internationally agreed framework document, the Hyogo Framework for Action, HFA (www.unisdr.org/eng/hfa), clearly calls for the "effective integration of disaster risk considerations into sustainable development policies, planning and programming at all levels, with a special emphasis on disaster prevention, mitigation, preparedness and vulnerability reduction" (HFA, strategic goals; § 12, lit. a). In Pakistan, in general and in the Northern Areas in particular a comprehensive (holistic and integrated) approach towards the integration of disaster risk reduction issues into sustainable development is still missing. Therefore, many development projects are damaged or even destroyed by different natural processes within limited time after completion.

In-depth information about the prevailing risks of multiple hazards would be crucial in order to make development projects sustainable and risk free and to provide safety for human beings and their livelihood. However, the information about magnitude and impact of natural events are rarely documented. Even if occurring frequently, such risks and the subsequent disasters are not well perceived and people as well as development and humanitarian agencies have limited awareness for disaster risk reduction. Maps which would represent natural features or would even provide information about prevailing hazards and risks are completely missing. The development of such tools is of utmost importance, particularly in the light of the fast development observed in the area. Especially the information about hazards is completely missing. The analysis of hazards (and the resulting risks), their assessment and evaluation and the proper representation on maps would provide the necessary information for the planners of development and humanitarian projects.

1.3 The Hazard, Vulnerability, and Risk Assessment

According to the HFA (§ 17) "the starting point for reducing disaster risk and for promoting a culture of disaster resilience lies in the knowledge of the hazards and the physical, social, economic and environmental vulnerabilities to disasters that most societies face, and of the ways in which hazards and vulnerabilities are changing in the short and long term, followed by action taken on the basis of that knowledge". Instruments such as hazard and risk maps for land use planning and land management as well for the emergency management are presently not available in the area. In addition, even the very basic topographic maps with appropriate scale and features are restricted especially for the strategically sensitive Northern Areas.

The research project is implemented in specific location (Sherqila village of district Ghizer (Punial tehsil) and in one of the fast growing village in district. Various instruments (hazard map, risk map) at a scale of 1:10,000 provide the necessary information for particular stakeholders. The dissemination of the main findings and of the respective products is of high importance. The present report describes these two instruments developed and provides overall information regarding risk conditions in the entire village. There is a clear focus on the hazards as this information is generally less appreciated and the local population and institutions have more difficulties to properly address such natural processes.

2 Goals and objectives

2.1 HVRA serving the overall goals of disaster risk reduction

The overall goal of the Hazard, Vulnerability, and Risk Assessment (HVCRA) is the provision of reliable data, information and tools for decision making in the field of holistic and integrated disaster risk reduction. The tools have to support the three main goals of the reduction of disaster risks:

- Reduction of existing risks through mitigation (structural and non-structural) and emergency preparedness
- Adaptation to the changing risk environment (e.g. environmental change, climate variability and climate change, vulnerability changes)
- Prevention of the further build-up of risks caused by inappropriate development, thus guaranteeing the sustainability of investments

Maps serve as indispensable products to guide the disaster risk reduction and development processes.

It is obvious, and has to be stressed that hazard, and risk maps or any other type of risk information are only the basis for effective and efficient disaster risk reduction. Assessments and maps alone do not prevent any damage or loss of life. Only the systematic integration of this information into planning and management processes contributes to a safer environment.

2.2 Objectives of the HVRA project

Hazard, vulnerability and risk assessment serves the development, planning and emergency management community to better understanding the natural, societal and economic conditions of a society under different levels of risk situations.

The main objective of the HVCRA project is the development and provision of various instruments showing hazards and risks to local stakeholders and the population in a limited geographical area. The instruments have to be easy to understand and readable by non-specialists. The following particular aims have been identified;

- ➢ to provide information about local hazards in the inhabited areas of Sherqila village Punial Tehsil
- ➢ to develop planning tools (hazard and risk map) where the local hazards and risks are represented in accurate and useable resolution and which are easy to read.
- ➢ to disseminate hazard and risk information to stakeholders in the area and to make them familiar about the multiple hazards existing in their surrounding environment.

To fulfil the overall goal and the aims listed above the project has the following specific outcomes;

1. Hazard map is developed for densely populated fast growing village: Sherqila: scale (1:10,000).
2. The relatively safe areas in the respective communities are delineated (green areas). The hazards are classified.
3. Risk map is developed. It is a simplified risk map which is developed by an overlay of the vulnerable elements on the hazard zones.

The maps have to be made available to the main stakeholders and the respective information has to be disseminated.

2.3 Limitations and obstacles

The main obstacles faced during the entire project implementation exercise were:

- Available topographic data: Topographic maps at a scale 1:50,000 exist however, their possession and use is restricted Topo-sheets with a scale of 1:250,000 are available, but these cannot be used for risk evaluation.
- Limited basic data: Meteorological or hydrological data (rainfall, peak river discharges, and specific discharges of respective catchments etc.) are difficult to obtain. The few data available do not permit to make full use for hazard assessment, e.g. the analysis of flood discharge in a particular small watershed.

3 Methodological approach

3.1 Conceptual framework

The assessment of risks from natural hazards considers a qualitative and quantitative analysis of hazards, of the elements at risk (vulnerability parameters) and of the existing coping capacities (reducing the vulnerability of a community). Conventionally risk is expressed by the notation

$$R = H * V$$

Some disciplines are stressing the capacity within the vulnerability

$$R = H * (V – C)$$

The risk factors are defined as follows (definitions in *italic* taken from www.unisdr.org):

H = Hazard: *A potentially damaging physical event, phenomenon or human activity that may cause the loss of life or injury, property damage, social and economic disruption or environmental degradation.*

The assessment of natural hazards addresses:

- Type of process (landslide, flood, rock fall, earthquake etc)
- Magnitude of process:
  - size of whole process (e.g. volume of a debris flow, size of boulders),
  - velocity of process (e.g. debris flow, snow avalanche, flood in a river)
  - depth of water during flood, accumulation depth of debris on fan
  - magnitude of an earthquake
  - duration of a drought.
  - any other parameter describing magnitude or intensity of a process

Probability of occurrence: Very often, the recurrence interval is used to express probability. In this project, the following recurrence intervals are considered:
- frequent events occur every 5 to 10 years,
- rare events occur once in a generation (10 to 30 years),
- very rare events occur once in 100-years.

V = Vulnerability: *The conditions determined by physical, social, economic and environmental factors or processes, which increase the susceptibility of a community to the impact of hazards.*

In this project the vulnerable elements (i.e. marking the physical vulnerability) are considered. These are mainly lifeline and other infrastructure, business elements as well as houses (where appropriate). The social, economic, environmental vulnerability factors were not directly addressed.

C = Coping capacity: *The means by which people or organizations use available resources and abilities to face adverse consequences that could lead to a disaster.*

The coping capacities refer to preventive and preparedness measures, and as such they contribute to the capacity for mitigation, response and/or recovery of a particular community.

R = Risk: *The probability of harmful consequences, or expected losses (deaths, injuries, property, livelihoods, economic activity disrupted or environment damaged) resulting from interactions between natural or human-induced hazards and vulnerable conditions.*

In a quantitative way, risk is expressed as a probable loss of life and/or of property in a given area in a specific period of time.

In this project, the emphasis is put on the hazards and the vulnerable elements. Risk is only shown by overlaying the vulnerable elements with the hazard zones.

3.2 Available data

3.2.1 Topographic Information

- **Topographic maps:** 1:250,000 are available for both areas. They are much generalized; the representation of the relief is poor. Topographic maps 1:50,000 exist; however, these maps are classified and were not available for the project.
- **Satellite imagery**: The project could use Landsat 7 multi-spectral-scenes of the area. The resolution of this imagery is 15 m.
- **SRTM Digital Elevation Model**: The NASA Shuttle Radar Topographic Mission (SRTM) is available as 3 arc second (approx. 90 m resolution) Digital Elevation Models. The vertical error of the DEM is reported to be less than 16m (http://srtm.csi.cgiar.org). The SRTM 90 m DEMs are provided in mosaiced 5 deg x 5 deg tiles.
- **Google Earth**: Google Earth served as an important tool for the identification and assessment of the hazards. Detailed images were available for Sherqila village (about 2 m resolution). The whole of Punial and Arkari is covered by imagery of 15 m resolution.

3.2.2 Geological information

The area is covered by a geological map titled "Geological Map of North Pakistan and adjacent areas of northern Ladakh and western Tibet". This map was compiled from various sources and edited by M.P. Searle and M. Asif Khan in 1998. It is printed at a scale of 1:650,000. The maps served as the main source geological source for the hazard assessment. In addition, a reference book (Geology and Tectonic setting of Pakistan by Kazmi & Qasim) was used to describe special features.

3.2.3 Hydro-Meteorological data

Climatic data was collected from the Pakistan Meteorological Department (PMD) and the Water and Power Development Authority (WAPDA)) for the estimation of climatic parameters. The climatologic station close to the area is located at Gupis in district Ghizer. Climatological data for Gupis station was available for the period 1955-2001. Other climatological stations in the region are at Yasin and Gilgit.

Table: 1 Main rivers in project area

No	Name	River	Latitude	Longitude	Elevation (m)
1	Gupis	Ghizer	36 10 N	73 24 E	2156
2	Yasin	Yasin	36 11 N	73 06 N	2661
3	Gilgit	Gilgit	35 55 N	74 20 E	1460

3.2.4 Past events

Past events (floods, debris flows, avalanches or earthquakes) were not systematically registered by any department or institution so far. However, a number of scientific publications provide information about GLOFs (Glacial Lake Outburst Floods) and related phenomena in the upper watershed of the Indus river system. Derbyshire and Fort (2006), or Hewitt (2004) describe major events which occurred mainly in the Hunza and adjacent valleys. Kreutzmann (2006) or Code and Sirhindi (1986) provides few local stories about destructions and flow level of GLOFs, and floods caused by the collapse of landslide dams.

An event data base was created during the course of the investigations for the village directly addressed (annexure- 9.1). Information was obtained mainly with interviews of local citizens, village heads and other village leaders. The main table is given in the Annex -A.

3.3 Data Processing

3.3.1 Satellite imagery and Digital Elevation Model

Remote sensing data needs to be processed prior to its use. Various image enhancement and rectification techniques were applied for the processing of satellite images and Digital Elevation Model (DEM). The data were processed by the Institute of Geographical Information System, National University of Sciences and Technology, Islamabad.

Different channels were combined to extract vegetation and water bodies from the images. Processing of satellite images and DEM was completed, including geo-referencing, image enhancement, and de-nosing. Further, these were clipped into District and Tehsil boundaries. Contour maps for Punial and Lutkoh Tehsils were prepared from the DEM. Finally, False Colour Composite (FCC) and True Colour Composite (TCC) images were ready to use, having a resolution of 15 m.

3.3.2 Geological Maps

The geological information is crucial for the understanding of the geomorphologic processes occurring in creeks and slopes. As an internal tool geological map was produced for Punial area, using the geological source map (as described in 3.2.2). The respective lithological units were interpreted with regard to slope stability and sediment production (table: 6 and figure: 11). Sherqila is comprised of single rock units and therefore the regional geology was taken in to consideration to know faults, and its buffer zone and production of sediments and slope instabilities with respect to other surrounding geological units. The map was produced according to the following procedure:

- Scanning and geo-referencing of the source map and defining the area of interest for digitization
- Digitization of the geological information shown on the source map within the area of interest (using Project System UTM Zone 43 N and ArcGIS 9)
- Development of river network from SRTM Data 90 m spacing
- Defining structural deformation zone along each fault trace shown on the geologic map through interpretation of Google Earth and satellite image.
- Lithology and structure have considerable influence on the stability of slopes. Assigning class levels of slope stability (three classes) and sediment production capability (three classes) to lithological units mapped within the area of interest. This classification is based on the geotechnical characteristics of the lithological units and described as;

Most Stable: This class is assigned to lithologic units comprising predominantly granodiorite, hornblendite, biotite granodiorite, plutonic units, basaltic andesite, gabbro-diorite, massive limestone, etc. These units are the strongest and generally form stable steep slopes. Frequent landslides and mass movements are not expected normally in such rocks. **Medium Stable:** This class is assigned to rock units comprising amphibolites, greenschist facies, muscovite, phyllites, micritic limestone, paragneisses, sandstone, slates, etc. These units are generally thinly bedded and laminated leading to frequent slope instability problems when adversely oriented. **Least Stable:** This class is designated to the rock units comprising alternating slates, shale, conglomerate, and rocks belonging to suture mélange. Moreover, the Quaternary deposits are also considered as least stable. Slopes in such units are generally least stable due to weak geotechnical properties. It has been observed in general that most of the slope instabilities and mass movements are generated along the faults and other structural deformations. Irrespective of the lithology, this class is also assigned to the rock units deformed along the geological faults.

- In general, the productivity of sediments is inverse to the stability class (highest in unstable formations, lowest in stable formations, with few exceptions).
- Two buffer zones with a radius of 2000 meters along regional tectonic features and 750 meters along local active faults were laid. Within these buffer zones the extent of deformation of lithological units is clearly enhanced. This increases the potential for sediments production and for slope instability. Large active debris fans and talus slopes are visible in satellite image.

3.4 Hazard assessment

3.4.1 Methods for hazard analysis

The assessment of hazards is based on three independent methods (for reference see for instance: Kienzholz et al. 1984:

- **Past events**: this method provides information about the magnitude (size, extent) of a particular event in a certain place. In addition, indications about damage are given occasionally. A time series can be established if information about several past events is available. However, this is possible only in limited cases. Information about past events is available from witnesses (very often elderly citizens) or in literature.
- **Field evidence**: this method analyses geomorphic features which indicate the possible occurrence of a hazardous processes (for reference see e.g. Selby 1993, Dikau et al 1996, Pierson 2005). This includes aspect, slope, bedding or other geotechnical parameters of rock and debris slopes. In addition, the field work includes the analysis of so-called "silent witnesses". These are features indicate to past activity in a particular location (e.g. fresh or weathered boulders at the foot of a steep cliff, the shape and extent of debris fans or the typical levees along the torrent bed and U-shaped torrent profiles which both indicate debris flow activity).
- **Modelling**: Hazards can be simulated using either very simple empirical relations or highly sophisticated numerical models. An important prerequisite for modelling of hazardous processes is good topographic data (e.g. a digital elevation model). Empirical relations like the travel distance of rock fall (equivalent slope of friction, see e.g. Scheidegger 1973) can directly be measured in the field.

The assessment of hazards in a particular location should always be based on several methods. This adds to the reliability of the information.

3.4.2 Type of hazards

A distinction is made between so-called remote hazards and local hazards. A similar approach has been followed in the Pamir Mountains (Schneider et al., 2004). For both types the effect is the same: a threat for local communities:

Remote hazards

Remote hazards are geomorphic processes which have there origin far away from the location of possible impact (several 10 to 100 kilometres or even more). In general, the damaging processes are floods, flash floods, or (in limited cases) debris flows. Often these processes are triggered by the outburst of lakes.

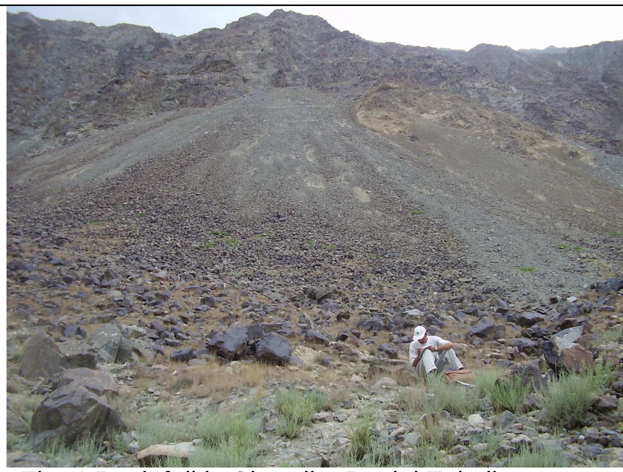
Fig:2 Satellite image of Utter lake Ishkoman Id # 03,
Google Earth, accessed June 2007)

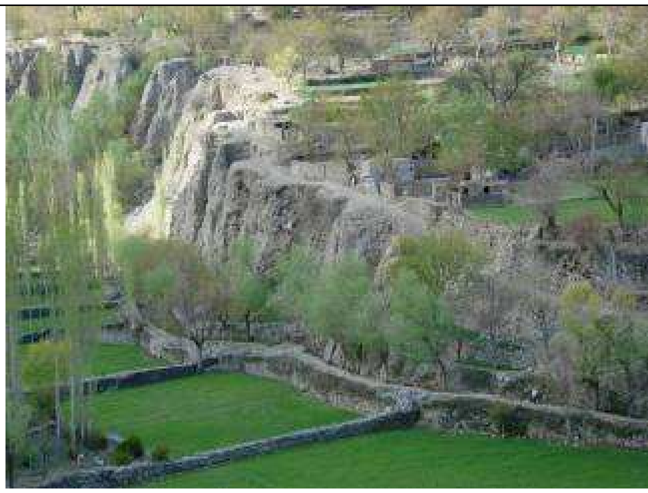
Lakes are either formed behind a natural dam (dam created by rock avalanche, landslide, major debris flow from a lateral river, surging glacier) or they develop within melting glaciers (dammed by moraines, sometimes by dead ice). The rapid outburst of lakes is the reasons for the floods. Triggering phenomena for an outburst are (Costa and Schuster 1988, Costa 1988):

- sudden displacement of water in the lake (e.g. by a snow or rock avalanche travelling into the water body) thus creating a flood wave which can overtop and erode the retaining dam
- instability of the retaining dam due to seepage
- increase in discharge and overtopping and eroding of retaining dam

Local hazards

The relevant local hazards (processes which develop in the vicinity of the impact zone) in the Northern Areas and Chitral are:

Debris flows occur in almost all steep perennial streams and dry channels (nalla) and reaches in to the settled premises of the village. They are triggered by long lasting rains, heavy snow melt or thunder storms. Talus slopes and moraine deposits are very susceptible to produce small- to large-scale debris flows.	 *Fig: 3 Fresh debris flow deposits at Sherqila (Punial)* Photo by Ejaz Karim, August 2000
Rock fall and rock avalanches are the common hazards in the entire project area. Shattered, jointed and fractured rock slopes are prone to produce boulders of various sizes. The magnitude (e.g. size of block) and intensity (e.g. travel distance) of this hazard is subject to slope parameters such as joint patterns and spacing, nature of rocks and types of lithological units, geometry of the slope, etc.	 *Fig: 4 Rock fall in Sherqila, Punial Tehsil* Photo by Ejaz karim, April 2007

Bank collapse is very common along the escarpments of river terraces and alluvial fans. The main triggers are undercutting of the bank by flowing water or infiltration of water from top (rain water and irrigation system).	 *Fig: 5 Sherqila (Punial tehsil), potential bank collapse Photo by Ejaz Karim, April 2007*
Snow avalanches are almost common in high altitudes (above about 3000 m a.s.l.), but during abnormal climate conditions snow avalanches can reach lower altitudes as well.	 *Fig: 6 Snow avalanche reaching settled area of village, Punial Tehsil Photo by Ejaz Karim, April 2007*
Floods usually take places during intensive snow melt or long lasting rains. The level of water gradually increases and overtops from the river sections inundating the low laying areas. During these events lateral banks undergo erosion processes. Flooding by lake outbursts is reflected in the local flooding as well.	 *Fig: 7 Sharp meander produced at Sherqila village produced by 1905 Glof along the main River Ghizer.* A main perennial stream also flowing across the village towards western side of the village, Photo from Google Earth, April 2007

In some areas a clear overlap of processes can be observed: Snow avalanches occur in many cases in the same gullies (nalla) as the debris flows. In addition, they show similar travel distance and accumulation pattern.

Fig: 8 Overlap of snow avalanche, debris flow and rock fall processes

Photo by Ejaz karim, April 2007

Under more humid conditions debris flows can develop within steep talus slopes. These conditions are particularly relevant in case of climate change.

Fig: 9 Huge talus slope prone to debris flow during humid climate conditions.

Photo by Ejaz karim, April 2006

3.4.3 Magnitude and frequency considerations

Different critical parameters were identified for each hazard to determine triggering conditions (pointing to frequency), travel distance or magnitude of event (cf. Hoek and Brey 1984 or Selby 1993). These parameters vary entirely for different hazard types regarding their source and impact areas. Here the parameters for rock fall are explained.

Details for other hazards can be found in Annex –B (data collection forms).

Parameters defining source area	Slope geometry (length, height) Slope geology Dip and strike angles of slope Nature of slope (consolidated/unconsolidated, shattered, jointed, fractured) Structural parameters of the slope like number of Joints, joint persistence, joint spacing Type of failure
Parameters defining impact area	Ground longitudinal profile Boulders at the foot of the slopes Travelled distance
Parameters defining magnitude of process	Size/volume of boulders
Parameters defining frequency of process (probability of occurrence)	**Confirmed:** fresh signs (active) rock faces **inferred:** phenomena are clear but look already weathered, no recent activity **potential:** conditions in source area are given that a process can occur. However, there are no indications for past occurrence

The hazards were classified according to their frequency (confirmed, inferred, potential). A recurrence interval was attributed to these three classes. The magnitude was finally not taken into account, as most of the processes have a high magnitude, capable to destroy buildings when occurring. This is a simplification of the hazard classification (see below).

3.4.4 Representation of hazards in maps

- **Overview map:**
  In the overview map the remote hazards are shown. The scale for Ghizer watershed is 1:250,000. The following information is given:
  - Earthquakes: Historic seismic data, main faults and particular seismic zones
  - Relevant existing lakes with a certain probability for failure
  - Possible valley blockages, where lakes could be formed behind natural dam
  - Possible lake formation on melting glaciers

- **Hazard map:**
  The hazards are classified using a notion of probability of occurrence. There is the following scheme adopted, resembling a traffic light:

Hazard class	Probability of occurrence	Recurrence interval	Legend
	in a given year	occurring once in	
Confirmed	0.2 to 0.1	1 - 10 years	Red
Inferred	0.1 to 0.03	10 - 30 years	Orange
Potential	0.03 to 0.01	30 - 100 years	Yellow
No known hazard			Green

With the hatching of colours the close alternation of safe and unsafe places are indicated (e.g. minor depressions where water can flow).

3.5 Vulnerability and capacity assessment, risks

Vulnerability, capacity and risk assessments are carried out separately through following approaches in parallel;

In order to assess the vulnerability of particular elements on micro level considered only physical exposure (location and distance from danger) of the elements (houses, schools, prayer facilities and health centers etc.) rather than its structural type and components.

To map the vulnerable elements, global positioning system (GPS) and data collections forms were used. Co-ordinates of all community infrastructures like schools, hospitals, houses, and other critical and public facilities of the target villages captured by GPS and plotted over hazard maps as a separate layer to reflect the vulnerability factor.

Physical vulnerability assessment reflects that if an element exists in red zone then it is highly vulnerable due to its physical exposure to certain location under single or multiple hazards irrespective of its structural composition and pattern as well social vulnerability conditions.

The logic behind to ignore the structural and social considerations of the elements at risk is because the pattern and composition of the structures and socio-cultural and economical set up with in the village as well as in the entire valley is almost the same. However to assess the social and structural vulnerabilities; a micro level research investigations are imperative. The current study can provide a firm platform to precede in-depth research further that classify vulnerabilities and risks with deep details.

while to evaluate the **capacity** of a particular village, the accessibility, type of hazards, its frequency and number of hazard sites, Past profile disasters, means of communications, development institutions working in the area, nearness from neighboring villages, emergency resources, awareness regarding natural hazards and its impact are taken in to account.

In this regard a quick survey was carried out to collect information regarding the different aspects the community, a formal format was designed and then meeting with village heads and elders, institution heads was arranged to gathered information related to population, available infrastructures which can be use during real time for emergency shelter, emergency stockpiles, community trained volunteers, number of critical facilities, information of past historic events, and livelihood options which is later on extracted to assess the capacity of the local communities to cope with expected potential disaster.

The level of **risk** is inferred by putting the layer of vulnerable elements like public houses, public infra structures and all critical facilities over the layer of hazards. Through this approach, the physical risk factor can be assessed and risk map can be generated. The hazard maps served as a basis for establishing a simplified risk map, as there is no quantification of the risks. Only qualitatively, the risk is shown.

3.6 Project implementation

3.6.1 Main steps for project implementation

The research project was implemented according to the following steps:

- July 2005:
  Selection of geographical location for project
  Development of working procedures (work plan, different arrangements)
  Review of existing literature
- Spring, summer 2006
  Remote sensing data (sat image, DEM) processing
- Spring to autumn 2006
  Extended field survey
- Winter 2006/2007
  Interpretation of field survey
  Preparation of maps
- Spring 2007
  Review and ground verification of field work
- Autumn 2007

  Report writing

3.6.2 Field survey

Pre-testing of toolkit

To test data collection forms was undertaken in Sherqila village in Punial (Ghizer district) in July. Data on different hazards were collected and the forms were filled. Criteria for hazards classifications were revised and toolkit were modified accordingly (given in the data collection form –see annexure-B).

Assessment of local hazards

An actual field survey was initiated soon after the required modifications in forms and methodology were completed. For the assessment of local hazards in the village, visited each and every site and entered data into the relevant forms. They indicated and delineated hazards on base-map/village clipping took photographs and other measurements; used simple tools & techniques and empirical formulas for hazard assessments and analysis.

Assessment of remote hazards

Sherqila is located at the down stream end of Punial Tehsil, the whole watershed of the district drains in to river Ghizer which flow through the toe of Sherqila village fan. Assessment of remote hazards was critical as they have potential of making colossal damages in case of an outbreak such as glacier lake outburst floods (GLOFs), Lake Outbursts, Major landslides and Rock avalanches etc. As the inventories of lakes, GLOFs and other possible valley blockages were made using satellite images and Google earth. This is better under methodological approach Key remote hazards were identified for aerial as well as ground reconnaissance. Aga Khan Foundation, Pakistan’s helicopter was requisitioned, to assess these hazards however, because of unfavourable weather conditions on these selected sites, the effort was abandoned and a ground reconnaissance is scheduled to assess some of these key remote hazards.

Conversion of field data in GIS-System

A comprehensive geospatial database was prepared to store collected data and to prepare different maps. Hazard data that was collected on village clippings during field survey were converted into GIS system using ArcGIS software. Hazard map for Sherqila village was prepared using pre-defined set of symbolism.

Extended field survey (spring, summer, autumn 2006)

The accessibility to the project area is subject to weather, abnormal weather conditions had created physical hurdles to carry out the field work. Due to complex nature of hazard sites (especially in hazard mapping) and debris flow incidents (disasters) in the target area (tehsil Punial), I remained engaged in site specific assessment and response activities. Therefore, field work was extended for three month.

Review and ground verification of field work (spring 2007)

All the maps were produced as draft, and draft products were ready for ground verification. A visit plan was scheduled in June 2007, to cross-check the draft products with ground features in the context of Hazard, vulnerability and risks. Many changes were made before the finalization of the end products

3.6.3 Dissemination of information to local communities and AKDN Leadership (spring 2007)

Procedures were made before sharing the final draft product with AKDN leadership and community as well as the FHAP CBDRM core staff. That who will be responsible to share the products and how these should be shared?

In this connection, one session was arranged at Focus Humanitarian Assistance Pakistan (FHAP) Office Karachi and all leadership of the different AKDN institutions were invited. Chairman, vice chairman Ex-chairman, Executive officer, Search and rescue consultant and board directors of the Focus Humanitarian Assistance Pakistan attended the session. I presented the background, purpose, importance and whole process of HVRA. Session came to its end with discussions, question and answers. Appreciating the work the senior executives agreed that hese tools can be used for land-use planning to ensure risk free development.

Before entering in to the communities, it was important to pass the Community Based Disaster Risk Management (CBDRM) training Officers who are directly involve with CBDRM activities and have direct access to community. In this regard, another session was scheduled at Gilgit to share these products not only with FOCUS Gilgit based staff but also the other national and international FOCUS unit’s staff. A thorough power point presentation and participatory group work was conducted by me.

4 Introduction Northern Areas

The northern areas officially named as Federally Administrated Northern Areas (FANA) are situated to the extreme north of Pakistan. To its north lies China while to the northwest Wakhan (Afghanistan) and the central Asian states exist, to the eastern sides are parts of Ladakh and Indian held Kashmir while to the south are the Areas of Pakistani held Kashmir. The district Chitral is situated on its western side (see fig. 1 &10).

Fig. 10: HVRA target area in Northern Areas

The Northern Areas are comprised of a number of valleys settled along the foothills of three mountain ranges; i.e. Hindukush, Karakoram and Himalayas.

Climate of Northern Areas

The climate of the area is considerably changing from southeast to northwest: from semi humid in the southern parts to dry and very dry in the extreme north. During monsoon the Nanga Parbat (8125 m) and surrounding mountain ranges (High Himalaya) act as a barrier for the vapour laden winds. The southern slopes of these mountains receive much rain, where as in the areas to the north the amount of precipitation is continuously decreasing. The following annual rainfall and temperatures are measured (Pakistan Meteorological Department).

Table: 2 annual rainfall and temperatures

Station	Distirct	Mean annual precipitation	Maximum monthly rainfall	Mean temperatures C° January	Mean temperatures C° July
Gilgit	Gilgit	129 mm	25 mm	3.3	36
Gupis	Ghizer	118 mm	24 mm	-0.5	35.1
Chilas	Diamer	173.2 mm	31.2 mm	0.9	39.6
Skardu	Skardu	216.4 mm	29.2 mm	-8.2	31.5

The Northern Areas are the source catchments for three main River named as river Hunza, Ghizer River and Skardu River which give raise the mighty Indus. Maximum and minimum discharge rates of along these rivers are;

Table.3: Minimum and maximum discharge of main rivers in Northern Areas

Name of River	Minimum discharge (m^3/sec)	Maximum discharge (m^3/sec)
Ghizer	57	1982
Hunza	65	2265
Skardu	254	8495

Northern areas are comprised of five districts named as Gilgit, Ghizer, Skardu, Ganche and Diamer Astore. The population of the region is about 1.5 million people. The entire population is Muslim and believes in different interpretations of the faith. People of the region live in rural communities and their source of livelihood is subsistence agriculture. However, after the construction of roads this area has been opened for the outer world and people have migrated to the urban areas of Pakistan. Due to its natural beauty and rich cultural heritage, this part of the world attracts thousands of mountaineers, trekkers and general tourists from around the world.

4.1 Ghizer District and Punial Tehsil

Ghizer District is northernmost part of the Northern Areas of Pakistan. Its capital is Gahkuch. Ghizer is a multi ethnic district and three major local languages are spoken such as Khowar, Shina and Burushaski. There are also a few Wakhi speakers in Ishkoman. Historically the region has been ruled by indigenous rajas (rulers) such as those of Yasin and Punial and later it was divided between the Mehtar of Chitral and the Maharaja of Kashmir. After 1895 all of Ghizer was annexed to Gilgit Agency which was directly ruled by the British Government.

Politically Ghizer District is comprised of four tehsil as given in the following

table: 3 with respective population;

Table:4 Tehsils of District Ghizer

S.#	District	Tehsil	Population
1	Ghizer	Punial	26159
2		Ishkoman	18731
3		Yasin	34738
4		Gupis	30044

The catchments of the Ghizer River are about 12,095 sq km. The main tributaries of Ghizer River include Karambar River, Ishkoman River, and Yasin River.

Punial is the commercial hub of district Ghizer and is one of the four tehsils in the district. The total area of Punial is about 1,700 square kilometres with a population of near 30,000. There are 35 villages in this tehsil, most of them settled along the main river (Ghizer River). Debris flow and river bank erosion are predominant hazards in the area. There is also likelihood of flooding since the valley bottom is located on a relatively large floodplain. For example in 2005, heavy rain and snowfall in district Ghizer caused loss to life and property. Roads, trees, crops, cattle and cattle-pens were badly affected by flooding and it also killed hundreds of animals (particularly the high grazing yaks) and damaged micro-hydel stations and farmlands in Punial and Ishkoman tehsils. Heavy land sliding and rock falls in the Gilgit-Ghizer road, closed traffic for several days. This valley has also several experiences of major GLOFs in the past.

4.2 Geology of the area

Northern Areas belong mainly to the Hindukush terrain and parts of Karakoram. Its geology is characterized by the occurrence of thick sedimentary series of the Tethys Zone (metamorphic) of northern Karakoram and north Hindukush and of the volcano-sedimentary sequences of the southern Karakoram. According to Burrard and Hyden (1908), the Karakoram Range originates from near Tudok and Aling Kangri (7314 m) in Tibet and extends up to Afghanistan. According to them” Karakoram and Hindukush ranges of mountains are different sections of the same crustal fold. The eastern portion of the fold is known as Karakoram range while the western portion is known as Hindukush range. Numerous geologic faults run across the district Ghizer, including the regional faults designated as Main Karakoram Thrust (MKT), Reshun Fault and Tirich Mir Fault. The faults have caused immense structural deformations to the lithological units exposed deteriorating the slope stability conditions and enhancing their sediment production capability. The entire Kararuram-Hindukush mountain regions comprised of different geomorphic features like rugged rocky ridges, snow peaks, huge glaciers, rivers, streams, gorges, steep valley slopes, huge debris fans, braided river channels, glacial moraines, narrow valleys, gorges, and remnants of the old river terraces.

The rock units exposed in the study area are designated with different codes and described briefly on the source map. A brief description of rock unit exposed in the sherqilla village is described as under while for regional geology of whole district Ghizer see attached geological map (Figure: 11).

Table: 5 Description of main rock formation in Sherqila Village and its surroundings, Tehsil Punial

Rock unit code	Description
Q	Quaternary Deposits (alluvium, moraines, rock avalanche deposits, scree slopes, snow avalanche deposits) not plotted on the map
Sv	Volcanic rocks (Basaltic andesites, rhyolite, pyroclastic flows and volcanic braccia)

In addition to the above, the uppermost parts of the areas covered with permanent ice and snow is identified separately on the geological map (Figure: 11 & table.6). The areas “not mapped” are also shown on the map.

Fig: 11   Geological maps of District Ghizer Northern areas of Pakistan

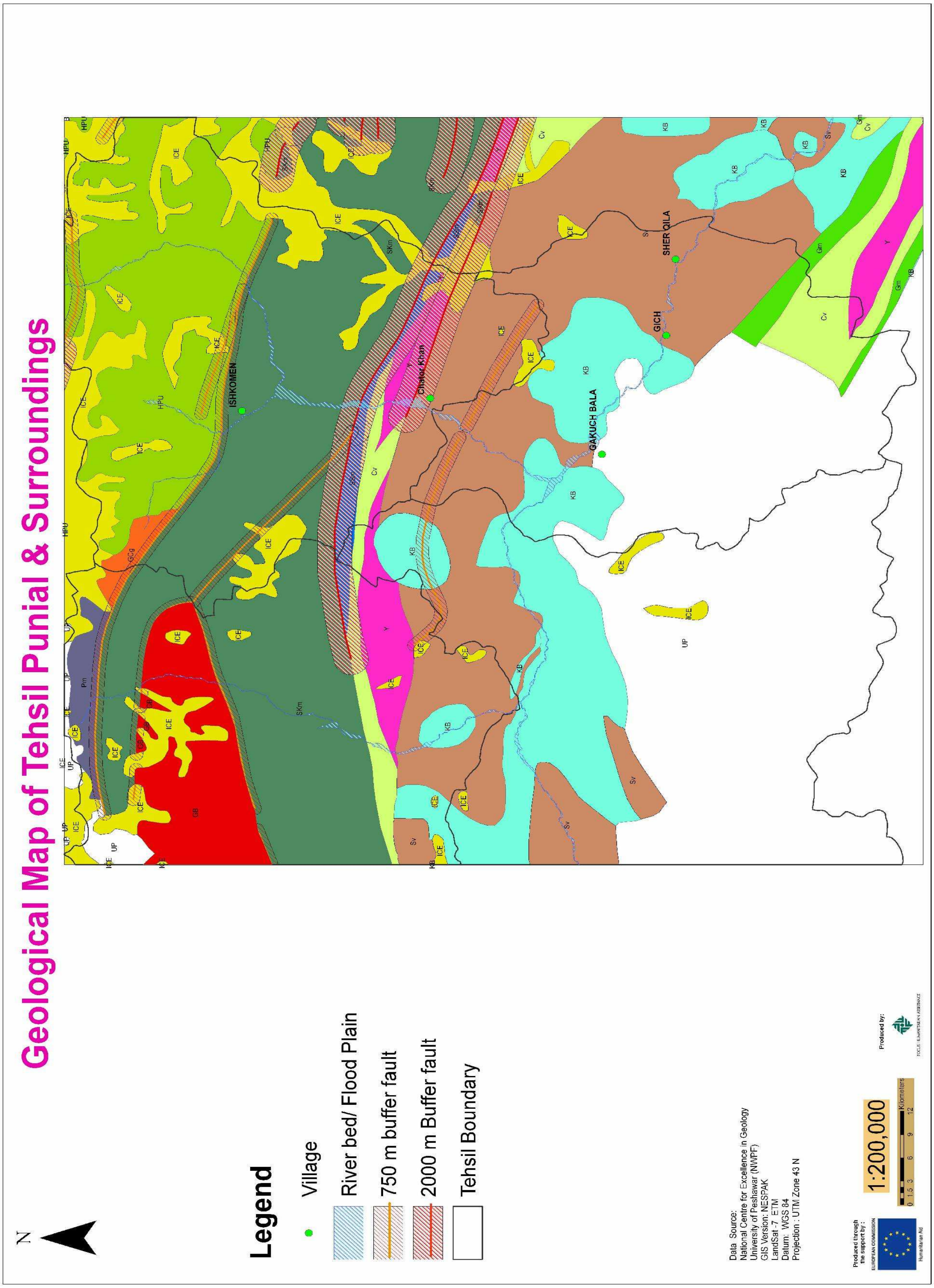


Table: 6 Stability classification details with respect to geology of the area

Formation Code	Description	Structural Deformation Details	Stability Class	Sediment Productivity Class
GCg	Muscovite, tourmaline leucogranite		Medium	Medium
GB	Plutonic unit (K-feldspar+quartz+plagioclase+biotite+Hornblende+garnet)		Most	Medium
HPU	Plutonic unit (Plagioclase+quartz+hornblende+biotite+garnet+K-feldspar)		Most	Medium
SKm	Paragneisses including interbanded pelite, marble, amphibolite, with rare ultramafic lenses	Highly deformed	Medium	Medium to Most
SSm	Suture melange (limestone, quartzite, and serpentine in a shely matrix)	Highly deformed	Least	Most
Sv	Basaltic andesite, rhyolite, pryroclastic flows, ignimbrite and volcanic breccias		Most	Least
Y	Intercalated limestone, sandstone, shale amd meta-volcanic rocks		Medium	Medium
Cv	Calc-alkaline andesite, also volcanic rocks		Most	Least
Gm	Meta-sedimentary rocks including greenschist facies slates, phyllite and psammite, minor basalts		Medium Least	Medium to Most
KB	Calc-alkaline gabbro-diorite, hornblende cumulates		Most	Least
Ice	Permanent ice and snow cover			
Up	Un-mapped			

5 Description of map products

5.1 Overview map: remote hazards in Ghizer

The overview map *(annexure-C Fig: 9.2 & for clear legend see-9.3)* mainly emphasises on the remote hazards which are building up in the remote locations in the upper catchments and in case of failure it create disastrous situation downstream areas. Sherqila village will be one of the many villages which can be suffering in-case of flooding. The map includes the following hazards:

- Earthquakes (fault lines and epicentres of past events)
- Existing lakes with a chance for an outburst
- Possible lake formation in glacial areas
- Possible valley blockage (and subsequent lake formation)
- Braided river sections (flood prone and lateral erosion susceptibility)

The overview map of Ghizer District (Ghizer watershed) covers an area of about 12,000 km^2. The scale of this map is 1:250,000. The overview map of Chitral District (with Arkari Valley in the centre) covers an area of approx. 2000 km^2. The scale is 1:100,000. For both maps the topographic background is the Landsat 7 satellite image.

The overview map is an instrument to raise awareness of local emergency services or development agencies for hazards originating far away from their zone of impact. In general, the local knowledge about these hazards is minimal or even not existing.

5.1.1 Earthquake information

Numerous geologic faults run across the area of interest, including the regional faults designated as Main Karakoram Thrust (MKT), Reshum Fault and Tirich Mir Fault (see fig:11). The faults have caused immense structural deformations to the lithologic units exposed deteriorating the slope stability conditions and enhancing their sediment production capability.

Major Regional Faults

These faults traverse mostly along the boundary of various regional mountainous terrains. The faults placed into this category include Main Karakoram Thrust (MKT), Reshum Fault and Tirich Mir Fault. These are mapped and plotted on the overview map, while there are other active faults which are not mapped. These fault lines are the source for intense seismic activity. In the last 30 years, about 30 earthquakes occurred having a magnitude > 3.7. For all the tremors the depth was relatively deep: about 30 to 100 km.

The Hamaran seismic zone

Documented record of seismicity consists of mainly earthquake epicentres located on the basis of modern instrumental recordings. This seismic activity is the result of movement along various active faults in the region. Hamaran seismic zone is classified as one of the most active seismic regions of Pakistan located at a distance of 35 km south of Gupis in Hamaran valley. The zone is marked in the overview map by a cross hatched symbol. There are frequent earthquakes of magnitude 3 to 5 (Kazmi & Qasim, 1997) with a hypocenters ranging from <50 to 100 km depths observed in this particular seismic zone. In recent years these earthquakes have caused much damage in Gupis and adjacent areas. However, no distinct active fault has yet been mapped in the region.

Past seismic activity

The overview map provides information about the past seismic activity. The epicentres with the year of occurrence are shown on the map (information taken from the Pakistan earthquake catalogue). Below, the table shows a summary of these past seismic events with their respective locations (coordinates), magnitude, depth of epicentres and occurrence date (time and year). The first column shows the serial number (of the Pakistan earthquake catalogue) of the epicentre points which falls in the area of interest.

Table 7: Historical seismic data for Ghizer District. (Pak-Met & GSP)

Historical Seismic Data of District Ghizer								
S #	Year	Month	Day	Time	LAT	LONG	Depth (Km)	Magnitude
7	1973	1	15	184844	36.060	73.360	33	3.8
39	1973	4	14	204609	36.110	73.490	33	4.1
96	1973	12	9	23652	35.880	73.260	33	5.0
206	1975	2	1	181651	35.970	72.980	70	4.9
238	1975	4	23	90727	35.870	73.240	79	4.8
994	1981	9	12	121717	36.090	73.450	33	4.3
996	1981	9	12	152522	36.290	73.250	33	4.1
1172	1983	8	11	80627	35.870	73.790	104	4.7
1404	1985	5	14	204545	36.290	73.390	33	4.6
1420	1985	6	24	230918	35.930	73.720	33	4.7
1651	1986	8	24	173745	35.840	72.940	44	4.8
1748	1987	7	11	124608	36.470	73.670	106	4.3
1904	1988	12	3	60448	36.230	72.650	33	4.8
1953	1989	4	19	73223	36.470	73.420	44	4.9
2030	1990	2	5	234926	36.570	73.250	75	4.0
2396	1992	3	1	61829	36.170	73.430	33	3.7
2437	1992	5	15	55701	36.010	73.190	33	4.3
2505	1992	10	13	133604	36.150	73.910	33	4.5
2548	1993	2	18	121444	36.710	74.070	27	5.0
2698	1994	3	30	163924	36.250	72.970	33	4.1
2890	1995	10	8	183801	35.990	73.500	33	3.9
5194	2002	5	19	84011	36.370	73.450	33	4.2
5288	2002	9	9	234657	36.080	73.470	33	4.1
5634	2003	9	20	135945	36.010	73.390	33	4.9

According to the seismic zonation map (www.munichre.com/en/ts/geo_risks) the Northern Areas of Pakistan fall into world's second dangerous zone with an expected intensity value of MMI scale VIII (Modified Mercalli Scale). During the last 35 years, no major earthquake occurred in the region; however, many seismic events are noticed and recorded.

Such high seismicity in a mountainous terrain results in frequent slope instability like rock fall, debris fall or other slope movements. As such, seismicity has to be considered as a major threat to the area and their inhabitants.

5.1.2 Existing lakes

The catastrophic drainage of lakes constitutes a major threat for villages in high mountain areas which are located along the main rivers. In 1905, as an example, a lake dammed by Karumbar Glacier (Ishkoman tehsil, Lake spot # 35, table #11) drained and produced a huge flood (Hewitt 2004), which destroyed many locations along Ghizer River and Indus River.

In the catchment basin of Ghizer River (11,900 km^2 at Gulapur) about 155 lakes and ponds were found based on an analysis of satellite imagery. Most of these water bodies are located far away from the inhabited areas of Punial tehsil. Out of the 155 lakes fifteen are considered to be relevant for potential collapse and producing considerable floods in the villages along Ghizer River in Punial. The rest of the lakes are either small (less than 1 million m^3) or the probability for a catastrophic failure is minimal (lake in stable, i.e. rocky conditions or dammed by old landslides).

Table 8: Characteristics of the 15 most important lakes in Ghizer District

Id	Tehsil	m .s.l. (meters)	Length (meters)	Width (meters)	Depth (meters)	Area (hac.)	Volume (million m^3	Discharge at origin			Discharge at	
								Huggel	Costa	average	Place	m$^{3/s}$
14	Gupis	4374	700	329	18	21.3	3.8	2000	1425	1700	Gahkuch	910
13	Gupis	4238	950	267	20	27.5	5.5	2702	1750	2200	Gahkuch	1290
12	Punial	4480	800	230	12	18.4	2.2	1274	1047	1200	Gahkuch	1000
11	Punial	4425	1084	302	12	28.0	3.3	1798	1325	1600	Singal	1450
10	Gupis	4322	450	236	20	25.9	5.0	2509	1664	2100	Gahkuch	920
9	Gupis	4304	675	300	20	26.5	5.2	2583	1697	2100	Gahkuch	1100
8	Gupis	3620	4990	334	35	160.0	56.0	18055	6403	8000	Gahkuch	4500
7	Gupis	3760	2125	404	33	90.0	29.7	10720	4485	6000	Gahkuch	3005
6	Gupis	4505	1065	167	19	23.3	4.3	2218	1529	1900	Gahkuch	1515
5	Gupis	2470	1100	250	5	27.5	1.4	864	803	800	Gahkuch	600
4	Gupis	2216	2240	270	8	48.0	3.8	2006	1428	1700	Gahkuch	1400
3	Ishkoman	3840	1838	590	30	110.3	33.1	11730	4769	6000	Gahkuch	2400
2	Ishkoman	3780	380	180	7	7.0	0.5	371	451	400	Gahkuch	343
1	Ishkoman	3710	925	384	16	22.5	3.6	1902	1377	1600	Gahkuch	1100

Explanation:

Id:	Internal identification number
Tehsil:	name of Tehsil
m.s.l.	altitude of lake (taken from Google earth)
Length:	length (L) of lake (measured on satellite image)
Width:	width (W) of lake (measured on satellite image)
Depth:	average depth (d) of lake (back-calculated from volume d = V/A), mainly to check reliability of volume estimate
Area:	area (A) in hectares (calculated with L * W)
Volume:	estimated volume (V in million m^3), calculated with a relation developed by Huggel (2004) $V = 0.104*A^{1.42}$ and adapted in few cases
Discharge at origin:	discharge calculated with formulas developed by Huggel (2004): $Q = 0.008*V^{0.82}$ and Costa (1988): $Q = 672*V^{0.56}$
Discharge at:	name of the place; discharge at place calculated with peak attenuation formula developed by Costa (1988) $Q(x) = 100/10^{0.0021*x}$ (with x = distance from origin in km)

Estimated peak discharge of lake outbursts (GLOF) has to be set in relation to peak discharge generated by rainfall and snowmelt. Discharge figures for Ghizer River and its tributaries are not available in Punial tehsil. They have to be estimated from information from neighbouring rivers. According to a study (GeoConsult 2007, 2) made in the Pakora River (Ishkoman tehsil, about 20 km north of Gahkuch; 90 km^2) reveals the following maximum specific flood discharge (m^3/km^2s) for rainfall and snowmelt discharge (estimated by regional method):

Table 9: Discharge data and specific discharge for Pakora River

Recurrence interval	**m^3**	**m^3/km^2s**
5 y	170	1.9
10 y	203	2.3
30 y	300	3.3
100 y	383	4.3

In the same report discharge data for Gilgit River are given as well as the parameters for the "Regional Method". The regional method provides an opportunity to calculate peak discharge for any place in the watershed, based on the size of the watershed (km^2) and empirical parameters. Adapting this method for the Ghizer River at Gahkuch (10,500 km^2) the following peak discharge is obtained:

Table 10: Calculated discharge and specific discharge for Ghizer River at Gahkuch

Recurrence interval	m^3	m^3/km^2s
5 y	2,800	0.27
30 y	3,500	0.35
100 y	4,100	0.39

It can be concluded that the possible outburst of a glacial lake produces floods which are generally smaller than a 30-years flood triggered by strong snow-melt and rainfall. Only lakes 8 and 7 (close to each other) could produce a flood which is equal or even bigger than a 100-years flood of the Ghizer River at Ghakuch.

5.1.3 Possible lake formation on melting glaciers

The melting of glaciers (e.g. due to climate change) causes major changes at the glacier tongue. Within lateral and frontal moraines, lakes can be created. A major flood is released if the sediment barrier is collapsing. The formation of such lakes is reported for many mountainous areas (e.g. for Nepal Himalaya, ICIMOD 2001), the resulting glacier lake outburst floods by many authors (e.g. Vuichard and Zimmermann, 1987, Hewitt, 2004).

The following locations (table: 9) were found in the watershed of Ghizer River where lakes could be formed on melting and deteriorating glacier tongues (based on satellite imagery assessment):

Table: 11 Possible lake formation on melting glaciers **(bold: estimated lake length larger than 1 km**

S.#	Tehsil Name	Easting (X)	Northing (Y)	Elevation
0	Ishkoman	36.6617870	73.6216870	4090
1	**Ishkoman**	**36.6714970**	**73.7312270**	**3905**
2	Ishkoman	36.6760700	73.7889420	4233
3	Ishkoman	36.6349370	73.9055330	4030
4	**Ishkoman**	**36.6116000**	**73.9068270**	**3914**
5	Ishkoman	36.6022920	73.8681550	3934
6	**Ishkoman**	**36.6208680**	**74.0834810**	**2932**
7	**Ishkoman**	**36.6891470**	**73.9859450**	**3512**
8	**Ishkoman**	**36.7716420**	**74.0254720**	**3698**
9	Ishkoman	36.7927930	73.9925040	3500
10	Ishkoman	36.5500620	74.1229780	3693
11	Ishkoman	36.5292390	74.0480450	3125
12	**Ishkoman**	**36.3829220**	**74.0384190**	**3950**
13	**Yasin**	**36.6420470**	**73.4041000**	**2763**
14	**Yasin**	**36.5752960**	**73.1166350**	**3817**
15	Yasin	36.6588550	73.0976440	4700
16	Yasin	36.6545910	73.0906090	4670
17	**Yasin**	**36.5402820**	**73.1188870**	**3675**
18	**Yasin**	**36.6669500**	**73.1422440**	**4137**
19	Yasin	36.6640300	73.2171277	4078

The size of the possible lakes varies from place to place. Places are marked in bold font where the estimated size of a lake (through satellite image interpretation) is expected to be larger than 1 km long.

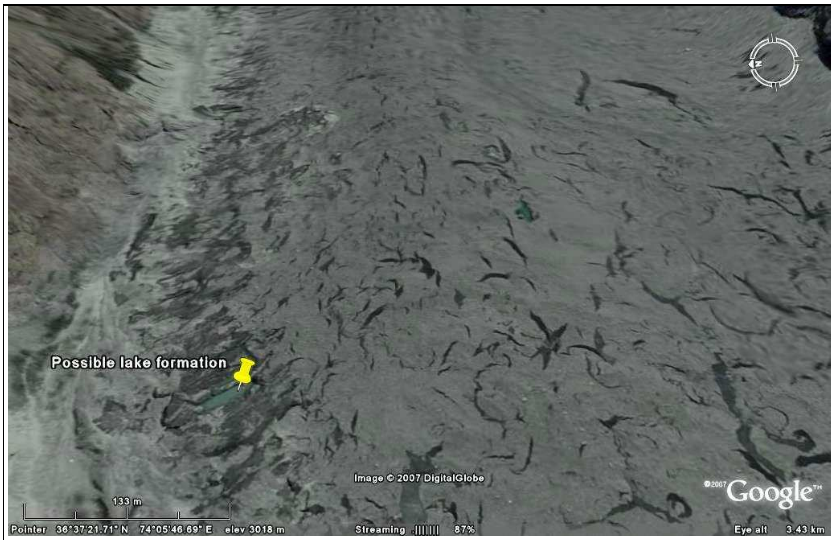


Fig: 12 possible lake formations due to melting of glacier and its incision.

5.1.4 Possible valley blockages

There are numerous evidences for blockages by rock avalanche, debris fan, landslide, surging glacier in the valleys of the Hindukush and Karakoram Mountain Ranges. Many of these old valley blockages have been described by various authors (e.g. Hewitt 1998, Derbyshire and Fort 2006, Iturrizaga 2006). The table given below (table: 12) shows the locations where valleys can be blocked due to debris flow activity and glacier surges. These blockages can cause the temporal damming of the river. The natural dams may collapse and the lakes formed behind may outburst catastrophically, causing destructions downstream. The potential for the formation of large lakes (> 1 km long is indicated by the symbol “x”.

Table 12: Possible valley blockage in the watershed of Ghizer River (Ghizer District)

S	Tehsil Name	X	Y	Z (elevation in meters)	Trigger	Potential for large lake (> 1 km long)
0	Ishkoman	74.010840	36.748332	3281	Debris flow	
1	Ishkoman	73.884967	36.846027	3724	Glacier	
2	Ishkoman	74.070898	36.625711	2873	Glacier, if advancing (1905 GLOF case)	X
3	Ishkoman	74.037145	36.665666	3066	Debris flow	X
4	Ishkoman	73.832507	36.345549	2034	Debris flow (huge sediment sources)	X
5	Punial	73.781005	36.288801	1969	Debris flow both sides (huge sediment sources and landslides along nalla)	X
6	Punial	73.858553	36.143103	1815	Debris flow from both sides (huge sediment sources)	
7	Punial	73.712339	36.079102	3747	Debris flow	X
8	Yasin	73.443695	36.577583	2643	Debris flow from both sides	
9	Yasin	73.433224	36.547391	2556	Debris flow from western side	X
10	Yasin	73.389555	36.449780	2492	Debris flow from Thaoi nalla	X
11	Yasin	73.376462	36.320195	2347	Debris flow from south-western side	
12	Yasin	73.282082	36.614800	3610	Debris flow from both sides	X
13	Yasin	73.273817	36.586398	4033	Debris flow	
14	Gupis	72.769322	36.091082	3258	Debris flow (huge sediment sources)	
15	Gupis	72.889112	36.165802	3085	Debris flow (huge sediment sources)	
16	Gupis	73.133621	36.164113	2470	Debris flow	X
17	Gupis	73.189405	36.183740	2396	Debris flow (huge sediment sources)	
18	Gupis	73.494534	35.944511	3704	Debris flow	
19	Gupis	73.457751	35.947282	3628	Debris flow	
20	Gupis	73.850687	35.975383	3525	Debris flow	
21	Gupis	73.307791	36.118630	2826	Landslide (old)	
22	Gupis	73.374134	36.248011	2188	Debris flow	X
23	Gupis	73.665837	36.267190	2060	Debris flow	
24	Gupis	73.467648	36.225961	2147	Debris flow	
25	Gupis	73.404042	36.240810	2190	Debris flow	
26	Gupis	73.433546	36.236716	2187	Debris flow	

Table 13: Possible valley blockage in the watershed of Ishkoman River (information taken from Iturrizaga (2006)

27	Ghizer	Ishkoman	73.850464	36.850586	3828	Glacier Surge	
28	Ghizer	Ishkoman	73.853067	36.849675	3834	Glacier Surge	
29	Ghizer	Ishkoman	73.89425	36.844139	3702	Glacier Surge	
30	Ghizer	Ishkoman	73.990431	36.787417	3601	Glacier Surge	
31	Ghizer	Ishkoman	74.040622	36.771442	3852	Glacier Surge	
32	Ghizer	Ishkoman	73.991725	36.745983	3559	Glacier Surge	
33	Ghizer	Ishkoman	73.994483	36.689344	3448	Glacier Surge	
34	Ghizer	Ishkoman	74.018006	36.681131	3394	Glacier Surge	
35	Ghizer	Ishkoman	74.068789	36.613594	2844	Glacier Surge	

Some the possible valley blockage locations in the above table (s. # 27 to 35) are taken from the research paper published ITURRIZAGA 2006). At these spots (fig. 13) the possibility of valley blockage is due to surging glaciers

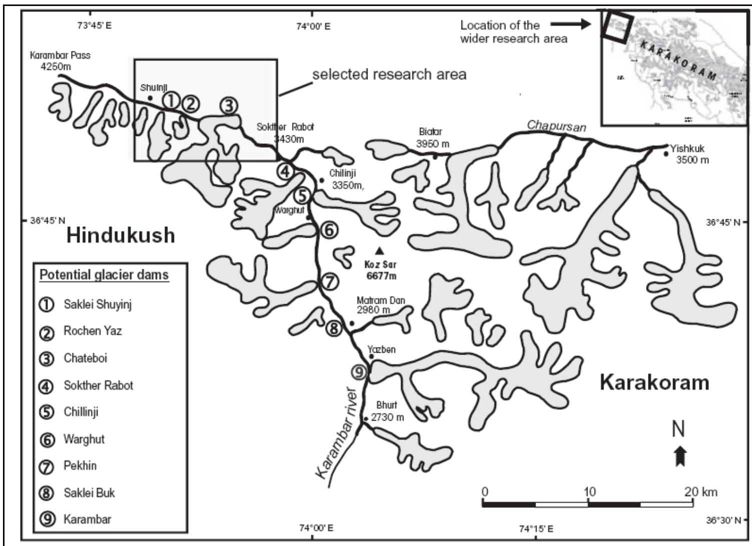


Fig. 13 Possible valley blockage by surging glaciers. Source: Iturrizaga 2006 Historical Glacier-dammed Lakes and Outburst Floods in the Karambar Valley (Hindukush–Karakoram)

An important process for the formation of valley blockages are glacier surges: the lakes are formed when the surging glacier blocks the main valley. According to Hewitt (1998), glacier surges are relatively short-lived episodes involving a sudden increase in movement of the glacier (10 to 100 times faster than normal), thus being able to block the main valley. This is achieved mainly by rapid sliding at the bed. Surge events may last from a few months to several years [Dowd-swell et al, 1991].

Surges tend to recur in cycles peculiar to each glacier involved and out of phase with general patterns of glacier advance and retreat. In regions with many surging glaciers, of which the Karakoram Himalaya is one, surges complicate the normally rather sensitive relations between glaciers and climate.

5.1.5 Hazard and risk map Sherqila

Sherqila village

Sherqila village is situated along the left bank (northern side) of Ghizer River at a distance of about 40 km from Gilgit city. Most of the inhabited area (7 km long, 1.5 km wide) is settled on debris fans. These are advancing from the steep slope onto an old river terrace. Parts of the village are on the river terrace (well above the river); however, other parts are near today’s river bed. A perennial stream along the NW end of the village is passing partially through settled areas. The rest of the creeks in the back of the village are dry channels (nallas) with abundant sediments (fig. 14). They are prone to produce debris flow during thunder storms and extended rainfall.

The village comprises of 7 sub villages and is home for about 8000 people with 800 households. Seven major educational facilities are located in the village (established by Aga Khhan education system, government and other sponsoring agencies). Farming is the main livelihoods option in the village. Village falls in double cropping zone. Overall Sherqila is prosperous as compared to other villages; it is growing very rapidly.

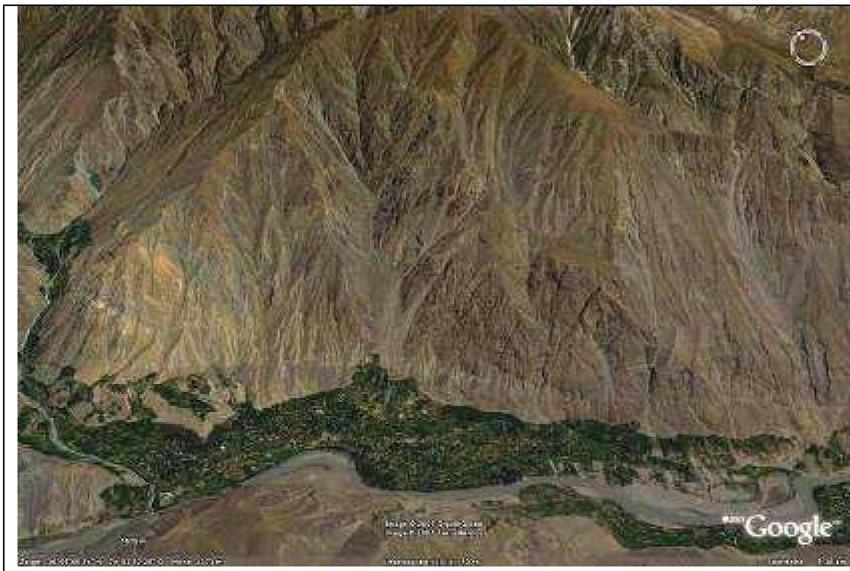


Fig: 14 Sherqila village from south-west. Debris fans develop at the bottom of a number of nallas. The slopes above the village are steep and completely dry. The eastern part of the slope immediately above the inhabited areas is much steeper than the western part. The Danjir nalla in the centre part is clearly visible. Dirani River enters from left side. Source: Google earth, accessed on 25 June 2007

Sherqila hazard map

Sheriqila village is mainly affected by the following types of hazards: rock fall, debris flow, floods, bank collapse. Under extreme conditions snow avalanches may occur. The distribution of these hazards is clearly dependent on the relief.

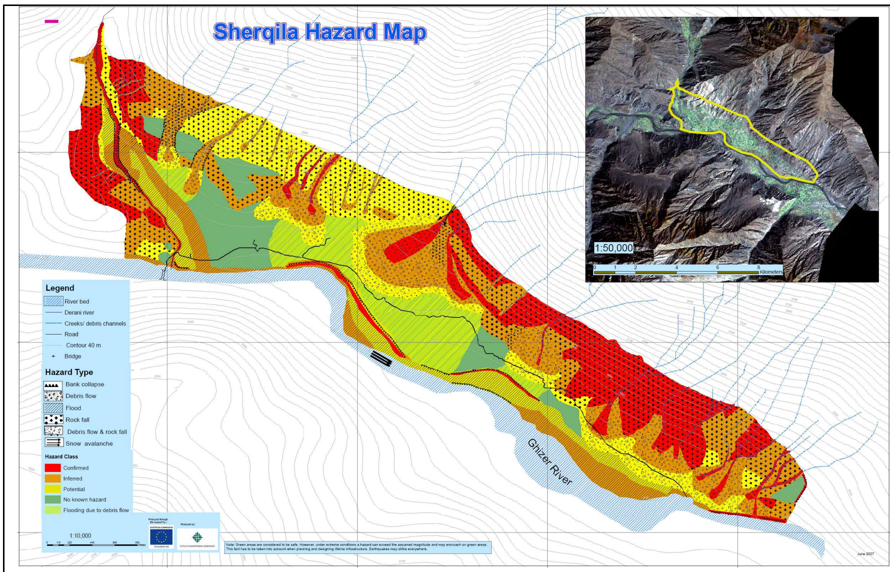


Fig. 15 Hazard Map of Sherqila

(For a clear hazard map see- annexure 9.5-D)

Rock fall:

Rock fall is the most wide spread phenomenon in the village. The slopes above the village on the eastern side are much steeper than on the western side (slope angle on the eastern side approximately 39° immedia tely uphill the inhabited area, 22° on western side). Even if the overall geo morphologic activity is higher in the western side, detached boulders normally do not reach the mapped area. Therefore, the degree of hazard is lower in the western part (yellow) as compared to the eastern part (red and orange). In a number of locations, the rock trajectories from eastern slopes can even frequently reach the settled area while towards western side the main activity lays above the mapped area. Only rare events can affect the inhabited area.

The escarpment of the second level of terraces (on the western side) is rather steep. Debris fall out of this open source has to be assumed occasionally (fig. 19). The travel distance of this process is limited as the accumulation area is rather flat.

Fig. 16 Loidass debris fall. Fresh boulders are lying close to the foot of the steep terrace. ***Photo by Ejaz, July 2006***

Debris flows:

Twenty five individual dry creeks are identified throughout the slope faces behind Sherqilla village. Thick deposits of unconsolidated sediments exist in the western side of the slopes. As the watershed area for each nalla is limited (less than 1 km^2) these creeks produce debris flows only under rare meteorological conditions. Most of the debris flows are marked as inferred (orange). If active, they can reach the inhabited area.

The large watershed in the centre (Danjir nalla, about 4 km^2) is active. In the last few years it produced a number of small-scale debris flows (fig. 17). Damage was limited. The potential for major debris flows exists.

The eastern side consist of steep and fractured hard rock. Small- to mid-scale events are occurring frequently. The potential for large-scale events with large travel distance is limited.

Major debris flows may cause flooding at the fringe of the fans. Water with mud may find small depression to flow towards the edge of the terrace. This close alternation of safe and endangered places is indicated with the yellow-green hatching. The probability of occurrence is considered to be low.

Fig. 17 Sherqila: Danjir Nalla with fresh debris flow deposits. Typical u-shaped profile of the channel and levees on either side of the channel
Photo by Ejaz, 11 April 2006

Floods:

The village is threatened by two rivers: Dirani River and Ghizer River. Dirani River has a watershed area of approximately 160 km^2. Floods in this river are of the following order of magnitude (using the regional method, explained in chapter 6.1.2):

- 10 years: 300 m^3/s
- 30 years: 450 m^3/s
- 100 years: 550 m^3/s

The discharge capacity in the vicinity of the hydro-electric power plant is of the order of 400 to 500 m^3/s (cross-section: width 60 m, height 1.5 - 2 m, area 100 m^2). A flood with a recurrence interval of 30 to 100 years will start to create problems. However, a major flood might transport large volumes of debris, thus considerably changing the river bed during an event. In addition, there is a steep nalla entering from the west side. This creek can deposit debris in the river, again contributing to a changing river bed. This increased probability for river bed changes is reflected in the hazard map with a possible overtopping of the left bank (about 1.4 km upstream of the confluence with Ghizer River) and subsequent flow along a depression to the east of the active river. The hazard class in this depression is inferred (orange) due to the probability for an overtopping.

The low-lying areas along Ghizer River in the east of the village can be flooded already during mid-scale floods (inferred hazard). A rare flood (30 - 100 years recurrence interval) from snow melt and rain or from glacial lake outburst will affect all the low-lying terraces.

Flooding in the river due to intensive snow melting, thunder storms, long-lasting rains, and remote lake bursts can cause inundations of low laying areas and toe erosions of these escarpments which can cause an ultimate failure of the bank (probability of 30 to 100 years).

Bank collapse:

Natural conditions (heavy precipitation) or flood irrigation can provide substantial moisture content of the soils, rendering the steep slopes unstable. This can occur any time. The degree of hazard is high (confirmed, red).

The main escarpment must have been actively shaped during the 1905 Karambar valley GLOF. A major flood in Ghizer River might affect the escarpment anew. However, the cross-section available revealed that this occurs only during a very rare event (30 - 100 y.). The degree of hazard is moderate (orange) to low (yellow).

Fig: 18 Sherqila, prayer hall at the edge of a high escarpment (along Ghizer River).
Photo by Ejaz, 6 April 2007

Sherqila risk map; Main findings specific to village

The Sherqila simplified risk map Fig: 19 *(For a clear risk map: see- annexure 9.6-E)* clearly indicates to the prevailing risks in the eastern and most western village parts. All types of vulnerable elements are at risk, including lifeline infrastructure.

- Only about 50 % of houses are in relatively safe area (green or yellow-green)
- About 45 houses are in high risk zones (mainly flooding, bank collapse, debris flow, rock fall)
- Three prayer halls (out of 7) are endangered
- One school is located in high risk zone (flooding from main river)
- The only access to the village (from the main bridge) is endangered by flooding from Dirani River.
- There is only 1 emergency stockpile for whole village available. The location is relatively safe; however, the distribution might be hampered in case of major activity in the nallas above the village.

Development of risks

The village is fast growing. The main growth (beside the construction in the central part) occurs in the eastern part of Sherqila. In this area, settlements are developing, very often in less suitable or even unsuitable places.

In case of a major shift in climate variability or a general change in climate towards more humid conditions might considerably alter the occurrence of hazardous processes. The many dry channels (above the village in the western section) or the edge of the terrace might become more active. This fact is considered in the hazard map (yellow hazard zone). However, events might become bigger than the assumed rare (100-years) event.

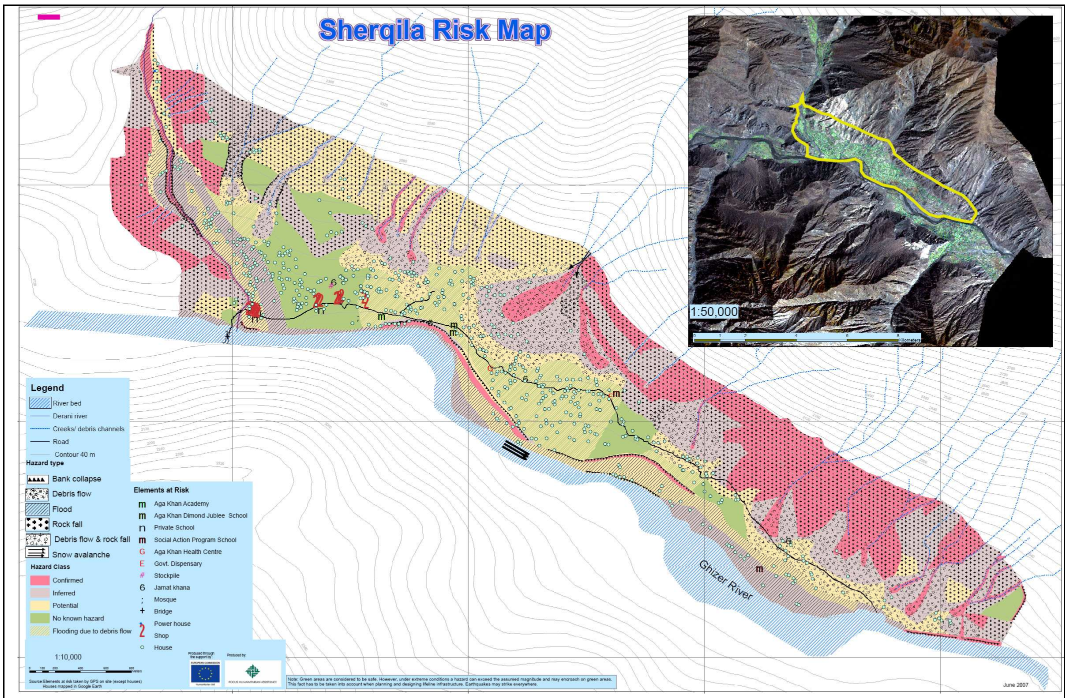


Fig: 19 Risk Map of Sherqila

(For a clear risk map see- annexure 9.6-E)

5.1.6 Scale consideration for hazard and risk maps

it was decided to test various scales for the hazard and risk map. Three different scales were used to test the appropriate scale for hazard and risk mapping for Sherqila. it was also checked how the topographic background could best be represented.

The pros and cons of the three scales used can be described as follows:

- The natural features which indicate the hazards can be properly represented in the map.
- The 40 m interval of the contour lines is minimal for this scale. However, the SRTM digital elevation model with a resolution of 90 m has clear limitations for the derivation of contour intervals of 40 m or less. In a number of locations (e.g. the representation of the Derani valley with the river) the contour lines do not represent the topographic situation properly.

- The available satellite image for Sherqila in Google Earth has a resolution which would permit to use this image as a topographic background (with the necessary processing).
- The scale is appropriate for the exact representation of individual houses and for other structures in the map.

One can conclude that a scale of 1:10,000 is appropriate for hazard and risk mapping. The implementation of the information into planning processes on village level is possible.

6 Main findings: prevailing risks

A. Remote Hazards

On the other hand, only such catastrophic events enabled life in this harsh environment: debris flows formed large fans where today's villages are located and the valley were blocked in many places by huge rock avalanches and similar processes, forming plains and terraces behind. Recurrence of such events in the settled areas creates devastative impact.

During extensive field work and interpretation of the satellite images remote as well as local hazards are evaluated.

Ghizer district is more fragile for earthquakes. The main tectonic elements like Main Karakoram Thrust Fault, Hamaran seismic zone, are other active faults are extending through the region.

155 existing lakes are identified, out of which 15 potential lakes out burst at different places are identified with in the entire district and most of lakes exist in Gupis tehsil.

Large scale valley blockages due to heavy debris flow, rock avalanches glacier surges and landslides (26 spots) identified.

Twenty possible lake creation spots are identified over glacier bodies as well as at the terminus of the glaciers

B. Local Hazard

Rock fall is the most wide spread phenomenon in the village. The slopes towards eastern sides are steeper than western side slopes above the village with an average angle of 39^0, even if the overall geomorphologic activity is higher in the western side, detached boulders normally do not reach the mapped area. Therefore, the degree of hazard is lower in the western part (yellow) as compared to the eastern part (red and orange).

In the eastern side of the slope above the settled area, rock trajectories reaches easily to the inhabited area while western side it could not reached to the habited part of the village because of gentle ground profile.

Bank Collapse is more common near the down slope end of the village. The rate of failure is directly related to human activities, like flood irrigation, construction activities and seepages, However in summers the rate of failure is higher than winter.

The village is threatened by two rivers: Dirani River and Ghizer River. Dirani River has a watershed area of approximately 160 km^2.

Near the Hydro-electric power station (see risk map) the river bed is aggrading progressively and there is enhanced chance of river diversion towards the habited village in-case of high flooding while the eastern part of the village which is mainly comprised of flood plain have a threat for inundation as village has already experienced during 2005. Similarly the remote lake out burst can create a catastrophic situation down the stream. Lateral erosion inundation while be at its extreme as village has experienced during 1905 Glof of karambar glacier moraine dam.

C. Vulnerabilities

During the research project mainly the vulnerable elements were identified and mapped. Other characteristic of vulnerability (i.e. the social, economic and environmental vulnerability) was not assessed because the difference from one to the other element and their socio-economic setting is not very different. In addition, it would require in-depth socio-economic assessments in the village.

- The population in the entire village lives in almost in cluster form and no scattered settlements.
- The building standard is equal all over the area: houses are made of stones without reinforcement. When such buildings are affected by a process (debris flow, boulder, earthquake) the building is likely to collapse, even with limited magnitude of the process.
- The population is generally poor and has little means to cope with calamities. But there is a strong network of the family.
- There are many family members working outside the area. This out-migration of the working labour has various effects: on the one side there are large amounts of money remitted to the area (i.e. there is a certain recovery potential). On the other hand, the out-migration constitutes a gender un-balance. In a number of villages there are many more female than male villagers. The immediate coping capacity is limited.
- The access to the area is an important issue for disaster response. Floods also may interrupt this access when banks and terraces are eroded.

Capacities

The capacities to cope with risks and disasters are not too different from one location to the other in Sherqila. The perception of risks and the capacities to manage risks and disasters can be characterized as follows:

- There is little knowledge available about hazards, vulnerabilities and risks; remote hazards are hardly perceived, even if many people in Punial tehsil know about the large 1905 flood. Risks from natural hazards might be of minor importance as compared to other risks in daily life (health, food security, etc.).
- In general, there prevails a fatalistic attitude towards risks from natural hazards. People have limited knowledge and, if they recognize hazards or vulnerabilities, they don’t think having a possibility to change the conditions.
- The preparedness of individual households for immediate disaster response is small; however, clan/family ties are strong. The assistance within the family and within the community is well working.

- Family members working outside the area contribute substantially to the recovery capacity of individual households. Money is flowing for rebuilding.
- Local (community) self-help is only at the start. In the village 4 VERTs (Village Emergency Response teams) approach has been introduced. In summer 2007 there were 4 VERTs in Sherqila with 250 trained members (50 male and 200 female) while there is one CERT for whole entire village on cluster level trained in community preparedness.
- Only one emergency stock pile is available for whole village.
- Structural protection is very limited or non-existent. If existing, the protection works consists of gabions (flood protection, e.g. Derani nalla in Sherqila).

Main risks

1. **Earthquake disaster**: Major earthquakes are rare but can affect the whole area. Secondary effects like rock fall, rock avalanches and bank collapse are very relevant. These slope instabilities may also severely affect the access to the area. In general, the village is located on sediment deposits (fans, terraces); these locations are more susceptible to amplify underground shaking than bare rock. Buildings and infrastructure are not very strong and, therefore, are likely to collapse. Similarly the along the river flood palin there is possibility of liquefaction in the thick sand strata which can cause the damage to built environment. The effects of a major earthquake would be dramatic. With interrupted access and limited local capacities, response and recovery would be difficult and slow.
2. **Flash floods** triggered by lake outburst: these are rare events; however, if occurring they have a devastating effect along the whole river. The effects are dramatic in the vicinity of the river only (flood plain, terrace edge); elevated and distant locations are safe. The warning time is very short. Most of the settlements (at least their edges) would be affected. Access to the area and within the area would be cut for days or weeks.
3. **Floods** in the main river caused by snowmelt or rainfall: major events are relatively rare. There is ample warning time as the water level rises much slower than during flash flood events. Major impact on traffic routes to be expected (whole reaches of the road might be washed out at various locations). Some low-lying areas (recently developed) along the river bank and flood planes are at risk even with a moderate flood (e.g. new school building at Sherqila).
4. **Debris flow** disaster: such processes occur frequently but they have limited spatial extent. However, in case of a major cloud burst, many nallas can be active during the same event, affecting settlements simultaneously. Parts of settlements in the village are at risk from this process. The process is highly destructive; houses and infrastructure in the debris flow track are likely to collapse. Areas on the fan which have not been affected for decades or even centuries can be reached. Warning time is very short (almost none for small nallas); therefore, people are at high risk.

5. **Rock fall**: This process occurs frequently in eastern side of the village where slopes are steep and shattered. Structures will collapse if directly hit (high process intensity). For individual boulder fall: there is no warning time. Major rock avalanches have precursors (increased boulder fall days and hours before the main collapse). Many houses near the slopes are at risk from occasional rock fall.
6. **Snow avalanches**: Settlements are at risks from snow avalanches only under extreme (very rare) meteorological conditions. In general, the avalanches occur in the nallas, which can produce debris flows.
7. **Bank collapse:** This process is highly important for traffic, as many roads go along terrace edges. On debris fan escarpments fields are often at risk from bank collapse.

7 Future development of risk conditions

The risk in an area is not static. It alters with time due the change of the individual risk factors. On the one hand, the magnitude and or frequency of the hazards may change due to developments (positive or negative) in the environment (climate variability and climate change, changing vegetation cover, overall environmental degradation). On the other hand, the vulnerability conditions may develop rather fast as the population is growing, areas are further developed, less suitable parts of the village are used for housing or other purposes.

7.1 Climate change

Climate describes the average weather conditions of a certain area in a given period of time. According to Maunder (1994; cited in Khan 2001) climate change is “a significant change in the mean values of a meteorological element during the course of a certain period of time, where the means are generally taken over periods of a decade or more”. Khan (2001) evaluated a possible climate change signal in the Upper Indus Basin of Pakistan, using hydro-meteorological data from 1953 to 1998. According to this study the meteorological and hydrological time series do not indicate a trend likely to be caused by ‘greenhouse warming’. A slight decline in mean monthly maximum temperatures may be explained by the occurrence of more rain (or of the cloud cover required for more rain). The findings of the study are not fully reproducible. In contrast to these findings, Archer analyzed data from 1900 and 1999 for Skardu and Gilgit stations:

- The temperatures at Skardu station show a clear upward trend in the twentieth century, the bulk of the changes occurred during the winter months.
- In Gilgit there is a mixture of positive and negative changes. Winters are generally warmer whereas spring and summer are cooler. The annual mean is slightly increasing.
- There has been a massive and remarkable change in precipitation for both stations (annual and seasonal increase).

These trends could have the following effects (Archer, page 5f):

- An overall increase in precipitation, if repeated at higher altitudes would lead to greater nourishment and vigour of glaciers.

- An increase in summer rainfall could lead to an increased potential for summer flooding from intense summer storms.
- There appears to be a strong association between rainfall and the occurrence of mass movement, especially landslides and debris flows which could lead to an increased frequency and severity of river blockage and subsequent landslides.

In addition to these effects one has to assume that the limit of permafrost is raising, making presently frozen slopes unstable. This effect is well-known in the European Alps (e.g. Huggel et al. 2004). A direct effect on inhabited areas is not to be expected (the areas of permafrost are in very high altitudes), however, this process might cause slope instability which can block valleys and it contributes to increased sediment production.

The findings by Archer (2001) are supported by observations of the local population. There is a perception of a shifting of winter towards spring and of more rain during usually dry summer.

7.2 Environmental degradation

Northern Areas is a rich mix of human and natural resources including cultures, languages, plants, animals and habitats (IUCN: Northern Areas Strategy for Sustainable Development). However, of major concern is the rapid growth in population resulting, inter alia, deforestation, depleted pastures, low productivity of agriculture and livestock, declining wildlife, soil erosion, degrading watershed.

The direct effect of such environmental degradation on the hazard situation is not obvious in the Northern Areas. The vegetation cover is already under natural conditions limited. However, intensive grazing of sheep and goats has a negative effect on the vegetation cover and might increase instability of scree slopes.

In general, a depleted vegetation cover increases the discharge in a watershed. As the percentage of vegetation cover in the steep watersheds of the numerous nallas is per se small, it is not clear whether this deterioration has a negative effect (more discharge, more sediments to be eroded). However, it can be concluded that it is going in a direction towards increased activity.

7.3 Changes in the hazard conditions

The impact of climate change and of the degradation of the environment on natural hazards is not obviously noticeable. The natural variability of the occurrence of hazards as such is relatively large. However, with care it can be concluded that:

- There seems to be a tendency for more humid conditions. Slope instability and debris flows are more likely to occur in the village. Particularly western side slopes of alluvial and moraine deposits and eastern side talus slopes might produce debris flows where they did not occur before.
- The frequency of storm events with local downpours is likely to increase. Debris flows in dry channels on the village slopes might occur more frequently than in the past or never taken place before. There might be a tendency for larger events with degraded vegetation cover.
- The failure of over steepened banks is likely to increase.

7.4 Changes in vulnerability conditions

Sherqila is settled on huge debris fan and river terrace, providing home for 8000 inhabitants, but comparing the prospective climate changes (ultimate enhanced hazardous situations) and its consequences with prevailing conditions of population growth, their expansion (lives and livelihoods) in the hazard zones development intervention with out assessing the prospective hazards and its possible impacts, many lives, assets (public, government, and other institutions) and financial investments are at high risk. The risk factor increases especially in village because being centre of the valleys and have easy access to rest of the main cities, people migrating from remote and far-flung areas towards it. Ultimately they become settled on these barren land patches which are hazard prone, where both their lives and property undergoes directly under high risk. The village Sherqila playing a hub for local business and growing very rapidly and the value of the land (even hazard prone) rising day by day and people investing blindly.

Adaptation measures to address the major impacts of climate change included new constructions, increasing public awareness, and sensitization. Adaptations were recommended in relation to institutional, organizational, and legal measures. The economic, financial, technical, cultural, and social aspects should also be considered.

Such kind of rapid, continuous and ill-planned development interventions can result a sever disaster (serious damage) even during a small magnitude event.

7.5 Use of Hazard and Risk maps

It is clear that the maps can not reduce the disaster impact but its proper implementation as a tool in the development interventions, as well as in hazard risk management can play a basic role for sustainable development and hazard risk management strategies. These maps can be used as a instruments in following areas of interests;

- **Prevention of further build-up of new risks and adaptation to changing risk environment**
    - Map with scientific clues and logics will be shared with community through community training officer who will convey the risk level and probability of occurrence of a certain hazard in a lay-man language
    - during awareness programs and community participatory filed exercises.
    - These maps can be used for land-use planning on local (village) level
    - Can be used to raise the awareness and building the capacities of local communities; and community leaders
    - Land management

- **Reduction of existing risks**
    - Prioritization for risks and their risk reduction activities in over all risk management

- Awareness building and capacity building for overall preparedness of local communities by using risk map and overview map
- Emergency management
- Maps will be used as a decision making tool for over all development planning by AKDN and other developmental organizations and local government
- maps can be used as a baseline data or information available on most hazardous sites for further investigation
- Prioritization of vulnerable sites for mitigations
- Identified Vulnerable spots in the hazard map which makes the settled area susceptible for future danger; are addressed by putting protective walls keeping in view the magnitude of the hazard (fig:20).

Fig: 20 Protective work along the river bank to protect the lateral erosion and bank collapse

Based on the findings following recommendations suggested

Detail investigation study of concerning lakes in Ishkoman and Gupis is imperative

The mapping of natural hazards and risks, and in particular the use of this information for land-use decisions and emergency planning is a highly delicate issue (a wrong assessment can put the people and their property in new risks or false sense of safety)

HVCRA exercise requires intensive field work and needs enough time (no quick assessments)

Misinterpretation of the map by end users can cause serious loss of both lives and property (end user needs an orientation how to read the map)

High resolution topographic base maps are important to represent features on their exact locations. Particularly true for the “green areas”

HVCRA requires high technical capacity in the field of risk analysis

Scale for hazard and risk map has to be 1:5000 or 1:10,000. Scale 1:25,000 is too small for planning purposes.

The remote hazards require additional field investigation

Limitations

- These maps do not includes seismic hazards, so from the prospective of any seismic activity green areas will also suffer
- Avoid to consider the areas near the hazard impact boundaries are safe
- In case of any future event the notion of probability and impact class may be changed (area should be revisit to update)
- Confirm zone can not reflects the magnitude
- Only Physical vulnerability has been taken in to account

8 Conclusions and Recommendations

The HVCRA (Hazard, Vulnerability, Capacity and Risk Assessment) and the subsequent mapping of hazards and risks in Sherqila revealed the following:

Risk conditions

In the Northern Areas the so-called mountain hazards (among others debris flows, rock fall, floods, or snow avalanches) are omnipresent. They constitute a considerable risk for the people, their life and livelihood. The most important events with the highest potential for damage and death toll are major floods and flash flood in the main rivers, and earthquakes. Such large-scale events are rare, but disastrous when occurring. The most frequent events with considerable damage almost every year, but limited spatial extent are debris flow disasters, as almost all settlements are located on debris flow fans.

In the target village the vulnerabilities are relatively high and the capacities to cope with risks and disasters are low. The overall awareness for risks and risk reduction is very limited. Pressing needs for land and for livelihood are outranking the risks from natural events.

Development of risk conditions

Risk is not constant: hazards are changing and vulnerabilities develop in one or the other direction.

There are indications for an impact of climate change on the hazard conditions. With more humidity the likelihood for slope processes (floods, debris flows, rock fall, bank collapses) is increasing. More humidity, on the other hand, would constitute better conditions for the growth of vegetation. A more dense vegetation cover would then constitute, in contrast, more instability of slopes and banks.

On melting glaciers the development of lakes is possible. Such lakes develop relatively fast and can break out producing catastrophic floods (GLOF). Lakes may also develop through the damming of valleys (large rock avalanches or debris flows, surging glaciers).

In the past few years the physical vulnerability increased remarkably in the area. Many new houses and infrastructure were built in unfavourable conditions. Such kind of rapid, continuous and ill-planned development interventions can result in a sever disaster with serious damage even during a small magnitude event. On the other hand, the capacity to cope with disasters is slowly increasing with newly built local response teams and with external money for recovery.

Methodological issues

The HVCRA project clearly showed that hazards, vulnerabilities, capacities and risks can be identified, analysed and mapped in a systematic and practical way. The HVCRA exercise further showed that

- It requires intensive field work and needs sufficient time and resources (no quick assessments). The financial resources for this type of work looks high, but compared to prevented losses these costs are small.

- the assessments require a multi-disciplinary approach with the relevant specialists (natural science personnel, social scientists, etc.)
- the (field) analysis of hazards is the most time-consuming process. It requires experienced personnel, repeated field visits and good basic information (topographic maps etc.).
- a single product (map) cannot show all the necessary information. The scale-issue is of high importance.
- the maps need to be easy to understand for successful implementation on village or tehsil level. The traffic light scheme (red-yellow-green) turned out to be easy understood.
- the proper scale for planning purpose on tehsil level is 1:50'000. On village level a scale 1:10,000 or 1:5,000 is recommended for hazard and risk maps. Smaller scales do not show the details (individual houses, infrastructure).
- the topographic background map and terrain information (elevation model) has to be in accordance with the hazard map.

Limitations

- Many issues could only be addressed on an overview level (e.g. remote hazards were assessed by satellite imagery, the necessary field work was not possible)
- The maps do not include seismic hazards (no micro-zonation performed). Therefore, the green areas will suffer from seismic activity as all the other areas do.
- The hazard classes do not reflect the magnitude of the processes. This is of limited importance as the magnitude can be considered high for most cases.
- The required topographic background (good satellite map, reliable contour lines) is missing for the detailed hazard map.

Recommendations

To complement the HVCRA project the following recommendations can be given:

- Detailed field investigation of lakes in Ishkoman and Gupis is necessary in order to have a better understanding of the probability for possible lake outbursts.
- Seismic micro-zonation would add to the comprehensiveness of the hazard maps. However, this is a rather costly task.
- Misinterpretation of the map by end users can cause serious loss of both lives and property. The end users need in-depth orientation on how to read the map (E.g. any boundary between hazard classes is a fine line on the map. In nature, however, this is a transition zone. This has to be understood when reading the map).

- Future work should as well include the notion of magnitude of process.
- In case of any future event the existing maps need to be reviewed and updated.

Risk assessment and mapping is a highly delicate issue. The use of this information for land-use decisions and emergency planning can put people and their property at risk or false sense of safety with wrong assessments.

Prevention and Mitigation Measures

- The confirmed hazard zones should be avoided for any type of construction in future
- Inferred hazard zones can be used for settlement (if construction is critical) after a detail site investigation and with proper structural measures.
- Along the longitudinal profile of the nala an appropriate x-section area should be left (with out encroachment) that would help to flush the debris load
- Development of permanent artificial features should be avoided in the nala section which could cause an obstacle during debris flow
- Vulnerable spots should be consider for potential hazard risk reduction by applying structural measure like diversion dykes, retaining structures, protective bonds (Gabion structures) diversion channels.
- In critical areas the exposed settlements and properties should be shifted to the safer places
- Awareness campaigns are crucial to reduce the ill planed development at community, institutional and administrative levels to reduce the economical losses
- A firm inter-institutional collaboration is essential for risk free development
- Indigenous and available technical early warning systems are imperative to inform the community on real time. These early warring systems may be;
    - Dissemination of weather forecast to remote location
    - Dissemination of precautionary measures to community during abnormal climate conditions
    - Monitoring of existing lake formation and their breach
    - Monitoring of stream profiles after debris flow and potential valley blockages
    - Early warning notices subject to season in a year;
        - February to April---------Snow avalanches
        - June to August-----------Debris flow and riverine flooding/bank collapse & erosion
        - June to August-----------Thunder storm/long lasting rains/landslides

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9 Annexure

9.1 Annexure-A: Event register

Profiles of Events in Punyial Tehsil (District Ghizer) and Arkari Valley Chitral							
Rock and Debris fall							
Village	**Region**	**Type of event**	**Date**	**Triggererd by**	**Deaths**	**Injuries**	**Damages**
Sherqilla Mulkish	Punial	rock slide	Apr-05	heavy rains	_	_	cultivbated land timber trees and fruit trees
Sherqilla Rashmal	Punial	rock fall	Apr-05	heavy rains	_	_	cultivbated land timber trees and fruit trees
Sherqilla Loidass	Punial	derbris fall	unknown	heavy rains	_	_	cultivbated land timber trees and fruit trees
Sherqilla Mulkishst	Punial	rock slide	2005	heavy rains	_	_	house wall, productive land, foprests and fruit trees
Sherqilla Sultanabad-Dass	Punial	rock fall	Oct-05	heavy rains	_	_	productive land, fruit and timber trees
Sherqilla Derani Bala	Punial	rock fall	2005	heavy rains	_	_	1 house
Debris flow							
Sherqilla Sultanabad Dass	Punial	Debris flow		heay rain and thunderstorms	_	_	Productive Land & fruit , timber trees and irrigation channal
lower Derani	Punial	Debris flow	1975	heay rain and thunderstorms	_	_	Productive Land, fruit and timber trees and irrigation channal
Sherqilla Sultanabad Dass st#1	Punial	Debris flow	1993	heay rain and thunderstorm	_	_	Productive Land, fruit and timber trees and irrigation channal
Sherqilla Derani Bala	Punial	Debris flow	2005	heay rain and thunderstorms	_	_	Productive Land, fruit and timber trees and irrigation channal
Sherqilla aminabad	Punial	Debris flow	1989	heay rain and thunderstorms	_	_	Productive Land, fruit and timber trees and irrigation channal
Sherqilla Loi Dass	Punial	Debris flow	1985/ 86	heay rain and thunderstorm	_	_	Productive Land, fruit and timber trees and irrigation channal
Sherqilla Sultanabads dass Jalo Loat	Punial	Debris flow	1993	heay rain and thunderstorm	_	_	Productive Land, fruit and timber trees and irrigation channal
Sherqilla Rashmal mulkish	Punial	Debris flow	1986	heay rain and thunderstorms	_	_	houses, cattle houses,irrigation channels,water mill and cultivated land
Sherqilla sultan abad dass st #2	Punial	Debris flow	1993	heay rain and thunderstrom	_	_	Productive Land, fruit and timber trees and irrigation channal

sherqilla astanphari	Punial	Debris flow	1989	heay rain and thunderstrom	_	_	3 houses,1 irrigation channel, fruit and timber trees
sherqilla danjir	Punial	Debris flow	1980,2001,2002-2005	heay rain and thunderstrom	_	_	10 houses 50-60 cattle houses were damaged in 1980, 4 houses and 10-15 cattle houses were damaged,and 12 houses were partially damaged during these events
Sherqilla Ramsoot(Gonairgash)	Punial	Debris flow	1993	heay rain and thunderstrom	_	_	Channel,fruit trees,timber trees and caltivated land
EROSION							
Sher qilla(ramshoot)	Punial	erosion	1975, 2005	rise in water level,gradient variation and turbulant flow	_	_	agricultural land , fruit and timber trees and almost 100 canals of land
Sher qilla mageni phari	Punial	erosion	2005	rise in water level,gradient variation and turbulant flow	_	_	agricultural land , fruit and timber trees and almost 100 canals of land
Sher qilla(omphari)	Punial	erosion(gully#3)	2005	over irigation of land	_	_	no any damages
Sher qilla(omphari)	Punial	erosion(gully#1 &2	2005	over irigation of land	_	_	no any damages
Sher qilla near health centre	Punial	Erosion	2005	over irigation of land	_	_	no any damages
FLOODs							
Dirani nala(sher qilla)	Punial	Flooding	1975, 2006	heavy rains and intensive snoiw melting	_	_	productive land, fruit trees and timber trees
Sherqilla near electric power station	Punial	Flooding	1982, 2005	heavy rains and intensive snoiw melting	_	_	productive land, fruit trees and timber trees some cattles and sher qilla brigde irrigation channel
Sherqilla omphari st# 1	Punial	Flooding	june, aug 2005 and 1982	rise in water level, out brust of kurumber lake	1	_	productive land, fruit trees and timber trees
Sher qilla st # 2	Punial	Flooding	1905, 2005	rise in water level, out brust of kurumber lake	_	_	productive land, fruit trees and timber trees
Sherqilla st#3(ramsot)	Punial	Flooding	1905, 2005	rise in water level, out brust of kurumber lake	_	_	productive land, fruit trees and timber trees and a pryer hall
Sherqillla(golapur)st # 4	Punial	Flooding	1905, 2005	rise in water level, out brust of kurumber lake	_	_	productive land, fruit trees and timber trees , a prayer hall and some houses
Sherqillla umphari near wooden bridge st #5	Punial	Flooding	1982, 2005	heavy rains and intensive snoiw melting	_	_	electric power station, bidge ,cattles with cattles houses and productive land
Land slides	**-**	**-**	**-**	**-**	**-**	**-**	**-**
SNOW AVALANCHE	**Punial**	**Snowavalanche**	**2007**	**Heavy snow fall**	**-**	**-**	**-**

9.2 Annexure-B: Data collection forms

Hazard, Vulnerability, Capacity, and Risk Assessment

Community Baseline Survey for Disaster Management

Boxes (MAXO-Code): **M**= Measured value; Observation, **A**=Assumption, X=Unclear, still to ascertain, **O** =not ascertainable

1. SNOW AVALANCHE

No	Questions	Options	Answer	Code
	Village name			
	Tehsil name			
	Geographical coordinates		Latitude:---------------- Longitude:------------- Altitude:--------------- (f)	
	Photograph no. and facing		Picture #:--------------- Facing: ----------------	
	Sketch #			
	Data collection date	Dd/mm/yyyy		
Information on source area				
Q3	Slope angle of the source area	> 45° 30°- 45° < 30		

Q4	Slope profile	Convex Concave Uniform		
Q5	Ground surface	Smooth Rough		
Q6	Vegetation at source area	Forests Pastures and Grass land Barren		
Q7	Type of avalanche reported?	Wet Avalanche Powder Avalanche		
Q8	Deposits of avalanche visible?	Yes No		
Q9	Hazard condition	Confirmed Inferred Potential		
Q10	Any mitigation work has been done at this site	Yes No		
Q11	Is mitigation work effective?	Yes No		
Q12	Can the potentially affected area be mapped?	Yes No if, no; why not?		

ELEMENTS AT RISK

Name of element at risk	If yes then give the number	NK	Please record coordinates, where required and provide

	Conf	Infer	Pote			
Are there critical facilities (school, hospital, prayer hall, etc.) at risk?					N	E
					N	E
					N	E
					N	E
Are there individual houses at risk? or whole village?					Please indicate number of houses at risk in each cell	
Is irrigation or other infrastructure at risk?					N	E
					N	E
					N	E
					N	E
Is productive land is under the threat of this hazard?						
Is there any threat that above identified hazard strike and could block the main river?						

Criteria for Hazard Classification:

Confirmed hazard:

Indication by people

deposits of past avalanches

Inferred hazard:

Slope of the source area is 30º-40º

Concave

Smooth

Barren/Grassland

Potential hazard:

Slope of the source area 40º-50º

Slope is uniform

Rough

2. DEBRISFLOW/MUDFLOW

No	Questions	Options	Answer	Code
	Village name			
	Tehsil name			
	Geographical coordinates		Latitude:-------------------Longitude:---------------- Altitude:--------------- (f)	
	Photograph no. and facing		Facing: ---------------------Picture #: -----------------	
	Sketch #			
	Data collection date	Dd/mm/yyyy		
Information on source area				
Q1	Drainage type of main channel (at the point of consideration on the fan)	Dry drainage Wet drainage		
Q2	Drainage area (watershed)	at the fan apex	--------------------- Km²	
Q3	Is there any lake present in watershed area?	Yes No		
Q4	Slope (average slope of the channel in watershed)		------- (%) or -------- °	
Q5	Availability of debris in the main channel	Abundant Partly available River is mainly on the bed rock Large moraine		
Q6	Rock Type	Crystalline Rocks with abundant gravel and sand Metamorphic Rocks (clay, schist) with abundant fine material		

Information on debris flow track				
Q7	Indication for debris flow activity (transition zone)	Remnants of past activity Presence of levees V-shaped channel		
Q8	Indications for debris activity (Fan area)	Levees Lobes Coarse boulders every where Deposits (mixture of fine & coarse material) Reported by people		
Q9	What is the average slope of the channel at fan area?		---------- (%) or --------°	
Q10	Volume of debris accumulation of individual event	Volume of debris	Frequent event: ---------- m³ Rare Event: ------------- m³	
Q11	Possible causes	Out break of lake Torrential rains (long lasting or short intensive rain) Intensive snow melting		
Q12	Kind of phenomenon	Debris flow Mudflow		
Q13	Secondary potential threat (possible blockage of river)	Yes No		
Q14	Hazard condition	Confirmed Inferred Potential		
Q15	Any mitigation work has been done at this site?	Yes No		
Q16	Is mitigation work effective?	Yes No		

Q17	Can the potentially affected area be mapped?	Yes No if, no; why not?		

ELEMENTS AT RISK

Name of element at risk		**If yes then give the number**			**Please record coordinates, where required and provide name**	
		Conf	**Infer**	**Pot**		
Are there critical facilities (school, hospital, prayer hall, etc.) at risk?					E	N
					E	N
					E	N
					E	N
Are there individual houses at risk? or whole village?					Please write down the number of households in each cell.	
Is irrigation or other infrastructure at risk?						
Is productive land is under the threat of this hazard?						
Is there any threat that above identified hazard strike and could block the main river?						

N: no, Y: yes, NK: not known

HISTORIC PROFILE

	Name of the event	**Date/ Year**	**Dead**	**Injured**	**Other damages/ Description**

Criteria for Hazard Classification:

Confirmed hazard:

Fresh Indicators (levees, lobes, V-shaped channel etc.) along track or on fan

Reports by people

Inferred hazard:

Still connected with the system (Channel can be filled and flow can diverted)

Reported by people about debris flow events long time ago

Weathered indicators (old features) **AND**

Abundant debris in the source area with an angle > 17º (or 30٪)

Potential hazard:

Located on fan but no clear indicators (levees, lobes, U-shaped etc.)

Abundant debris in the source area >17º (or 30٪) **AND**

Presence of lake or large catchment area to collect water

3. ROCKFALL/ROCKSLIDE/DEBRISFALL/TOPPLE

No	Questions	Options	Answer	Code
	Village Name			
	Tehsil Name			
	Geographic Coordinates		Latitude:------------- Longitude:---------- Altitude:---------- (f)	
	Photograph # and facing		Picture #: ---------- -Facing: ------------ --	
	Sketch #			
	Data collection date	Dd/mm/yyyy		

Information on source area				
Q1	Slope angle		----------------------- -	
Q2	Debris slope type	Unconsolidated (loose) Consolidated (compact)		
Q3	Rock slope type	Shattered Jointed Bedded Massive		
Q4	Rock dip conditions	± perpendicular to slope Horizontal Vertical ± parallel to slope		
Q5	Frequency of failure	Frequent (> 1 per/yr) Common (1-10 yrs) Occasional (10-50 yrs) Rare (< 50 yrs)		
Information on accumulation area				
Q6	Accumulation area	Talus slope Rock cone Individual boulders		
Q7	Magnitude of individual boulders or of accumulated debris	Individual boulders < $1m^3$ Individual boulders > $1m^3$ $10m^3$ - 10,000 m^3 > 10,000 m^3		
Q8	Angle between accumulation area and cliff	38° 32 to 38° < 32°		
Q9	Hazard condition	Confirmed Inferred Potential		

Q10	Any mitigation work has been done at this site?	Yes No		
Q11	Is mitigation work effective	Yes No		
Q12	Can the rockfall area be mapped?	Yes No if, no; why not?		

ELEMENTS AT RISK

Name of element at risk	**If yes then give the number**			**NK**	**Please record coordinates, where required and provide name**	
	Conf	**Infer**	**Pote**			
Are there critical facilities (school, hospital, prayer hall, etc.) at risk?					N	E
					N	E
					N	E
Are there individual houses at risk? or whole village?					Please give the number of households in each cell.	
Is irrigation or other infrastructure at risk?					N	E
					N	E
					N	E
					N	E
Is productive land is under the threat of this hazard?						
Is there any threat that above identified hazard strike and could block the main river?						

HISTORIC PROFILE

	Name of the event	**Date/ Year**	**Dead**	**Injured**	**Other damages/ Description**

<u>Criteria for Hazard Classification (Individual Rock fall):</u>

Confirmed hazard:

Fresh Cliff **<u>AND</u>**

Fresh boulders in the impact area **<u>OR</u>**

Recent events explored by the community

Inferred hazard:

Old boulders **<u>OR</u>**

Shattered and/or jointed cliff **<u>AND</u>**

> 40º slope angle (source area) **<u>AND</u>**

> 38º (from the source to impact area)

Potential hazard:

Bedded or massive rock > 40º

Dip condition horizontal or vertical

> 32º (from the source to impact area)

Criteria for Hazard Classification (Rock Avalanche):

Confirmed hazard:

Fresh rock avalanche deposits **<u>AND</u>**

Fresh Cliff

Inferred hazard:

Old rock avalanche deposits **<u>AND</u>**

Concave portion in the rock cliff

Potential hazard:

Slope > 40º

Jointed or bedded rock foundation

Dip condition ±parallel

4. FLOOD

No	Questions	Options	Answer	Code
	Village name			
	Tehsil name			
	Photograph no. and facing		Picture #:----------------- Facing:--------------------	
	Sketch #			
	Data collection date	Dd/mm/yyyy		
Information for particular site (Site: ………………)				
Q1	River name			
Q2	Watershed area		---------------------- (Km²)	
Q3	Drainage type	Perennial seasonal		
Q4	Gradient of river bed		-------------------- (%)	
Q5	Cross-sectional area (active river)		--------------------(m²)	
Q6	Flow velocity and discharge capacity		Velocity: ---------- (m/s) Capacity: ---------- (m³s)	
Q7	Do lakes exist in watershed area which can break out?	Yes No		

Q8	Flood peak discharge		Annual:------------- (m³/s) 10 years: ----------- (m³/s 50 Years:------------ (m³/s) Extreme: -----------(m³/s)	
Q9	For which flood the Cross-section is sufficient?	Annual 10 years 50 Years		
Q10	Is river bed showing	Down cutting over the last few years Aggradations over last few years Stable		
Q11	Sediments Composition in cross-section area	Boulders Gravels Sand		
Q12	Hazard Condition: flooding upstream or downstream in cross-section	Confirmed Inferred Potential		
Q13	Any mitigation work has been done at this site?	Yes No		
Q14	Is mitigation work effective?	Yes No		
Q15	Can the flood area be mapped?	Yes No If, no; why not?		

ELEMENTS AT RISK

Name of element at risk		**If yes then give the number**				**NK**	**Please record coordinates, where required and provide name**	
		Conf	**Infer**	**Pote**				
Are there critical facilities (school, hospital, prayer hall, etc.) at risk?							N N	E E

							N	E
							N	E
Are there individual houses at risk? or whole village?							Please indicate number of houses at risk in each cell	
Is irrigation or other infrastructure at risk?							N	E
							N	E
							N	E
							N	E
Is productive land is under the threat of this hazard?								
Is there any threat that above identified hazard strike and could block the main river?								

N: no, Y: yes, NK: not known

HISTORIC PROFILE

	Name of the event	Date/ Year	Dead	Injured	Other damages/ Description

Criteria for Hazard Classification:

Confirmed hazard:

Fresh deposits (mainly sands)

Cross-section is not sufficient for10 years flood

Inferred hazard:

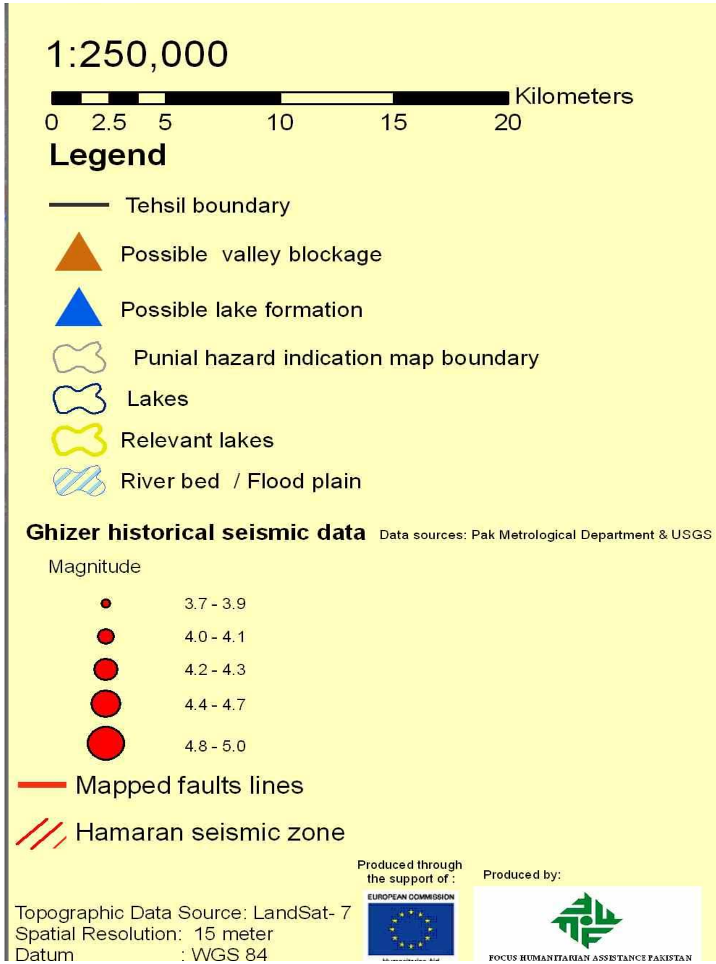
Cross-section is not sufficient for 50 years flood

Potential hazard:

Cross-section is not sufficient for extreme flood (e.g. lake outburst flood

9.2 Annexure C: Remote hazard map of District Ghizer Northern areas Pakistan

9.3 Legend for Figure: 9.2 (Annexure: C) Remote hazard map of District Ghizer Northern areas Pakistan



9.4 *Annexure C 1: Glacier Lake outburst: Estimation of water volume, discharge flow attenuation (all measurements are taken in meters)*

Glacier Lake Outburst: Estimation of water volume, Maximum discharge flow attenuation

Id	Tehsil	m a.s.l.	Length	Width	Depth	Area (hac)	Volume (million m³)	Dam Conditions	Triggering Process	Probability of failure	Discharge at Gahkuch m³/s
1	Ishkoman	3710	925	384	16	22.5	3.6	Dammed by debris flows from N-E and S-W face	Overtopping during strong snow melt; avalanche into the lake; lake 135 upstream (100,000 m³)	High	1100
2	Ishkoman	3780	380	180	7	7	0.5	Debris flow from west and east faces; No channel is visible; It has potential to grow.	Overtopping during snow melt; avalanches.	High	343
3	Ishkoman	3840	1838	590	30	110.3	33.1	Old lateral moraine and landslide or rock glacier; Surface flow over the dam is visible.	Snow avalanche; and over topping; Small lakes on glaciers are growing	Moderate	2400
4	Gupis	2216	2240	270	8	48	3.8	Dammed by debris flow from southern face	Overtopping if flood wave from up stream.	Moderate	1400
5	Gupis	2470	1100	250	5	27.5	1.4	Debris flow with huge boulders	Overtopping if flood wave from up stream.	Moderate	600
6	Gupis	4505	1065	167	19	23.3	4.3	Glacier moraine	Snow avalanche; Overtopping	Moderate	1515
7	Gupis	3620	4990	334	35	160	56	Landslide dam; Landslide from west face; Lakes may grow with new landslides; River overtops during low flow season.	Snow avalanche; New landslides; Failure of upstream lake	Moderate	4500
8	Gupis	3760	2125	404	33	90	29.7	Landslide dam; water is seeping through dam (dry channel)	New landslide; Snow avalanche	Moderate	3005
9	Gupis	4304	675	300	20	26.5	5.2	Landslide	Landslide	High	1100
10	Gupis	4322	450	236	20	25.9	5	Landslide	Landslide; Glacier moraine; Overtopping during snow melt	High	920
11	Punial	4425	1084	302	12	28	3.3	Moraine dam	Overtopping during strong snow melt	High	1450
12	Punial	4480	800	230	12	18.4	2.2	Dammed by landslide on eastern face	Overtopping during strong snow melt; Reactivation of landslide	Moderate	1000
13	Gupis	4238	950	267	20	27.5	5.5	Landslide	Snow avalanche; landslide	High	1290
14	Gupis	4374	700	329	18	21.3	3.8	Bed rock	Glacier avalanche	Moderate	900

9.5 Annexure D: Hazard map of Sherqila Village Tehsil Punial district Ghizer

2440

2280

9.6 Annexure: E Risk map of Sherqila Village Tehsil Punial district Ghizer

The end