Analysis of Community Resilience to Landslide and Debris Flow Hazard in Kohistan District

A Thesis of Master of Science in Disaster Management

Submitted By

AURANG ZEB

(Registration No # 2017NUSTMSDM00000204011)

A thesis submitted in partial fulfilment of the requirements for the degree of

Master of Science

In

Disaster Management

Supervised by

DR. ARSHAD ALI

Military College of Engineering, Risalpur

National University of Sciences and Technology (NUST), Pakistan

(2017-2019)

This is to certify that the Thesis entitled

"Analysis of Community Resilience to Landslide and Debris Flow Hazards in Kohistan District"

Submitted by

AURANG ZEB

(Registration No # 2017NUSTMSDM00000204011)

has been accepted towards the partial fulfilment of the requirements for the degree of

Master of Science

In

Disaster Management

____

Dr. Arshad Ali (Supervisor)

Associate Professor

Department of Environmental Engineering

Military College of Engineering (MCE), Risalpur,

National University of Sciences and Technology (NUST), Islamabad, Pakistan

DECLARATION

I **Aurang Zeb**, Registration No. **2017NUSTMSDM00000204011** declare that this research work titled "Analysis of Community Resilience to Landslide and Debris Flow Hazard in Kohistan District" is my own work. The work has not been presented elsewhere for assessment. The material that has been used from other sources it has been properly acknowledged / referred. None of this work has been published before submission of this thesis. This work is not plagiarized under the HEC plagiarism policy.

Signature of Student:

Date:

DEDICATION

Dedicated to my exceptional parents and adored siblings whose tremendous support and cooperation led me to this wonderful accomplishment

ACKNOWLEDGEMENT

I am thankful to Almighty Allah, who gave me strength and patience to complete my research. I would like to pay debt of gratitude to my advisor **Dr. Arshad Ali** whose countless inspiration and guidance made it possible to complete my research work. I am also extremely grateful to committee members, **Lec. Somana Riaz, Lec. Razia Sharif** and **Dr. Muhammad Jawed Iqbal** for their immense support and assistance in completing my thesis. The support and encouragement provided by **Lec. Somana Riaz** cannot be overstated. Her valuable guidance and subtle suggestion helped me through moments of stagnation during the entire duration of my research. His involvement and valuable time had a direct impact on its successful conclusion.

I would like to specifically pay my gratitude to all my colleagues and class fellows for enabling me to successfully accomplish my targeted goals during the course of my research work.

Finally I am deeply grateful to my parents and brothers for their financial, moral support and suggestions towards my progress in life. Without their prayers it would have not been possible for me to succeed.

(Aurang Zeb)

TABLE OF CONTENTS	
Contents	**Page No.**

Acknowledgement……………………………………………………………………… *V*
Table of Contents……………………………………………………………………… *VI*
List of Figures……………………………………………………………………….. *XI*
List of Tables………………………………………………………………………… *XIII*
List of Abbreviations…………………………………………………………............ *XV*
Abstract……………………………………………………………………………….. *XVII*

Chapter 1

Introduction……………………………………………………………….. 1-7

1.1 Rationale of the Chapter……………………………………………… 1
1.2 Background…………………………………………………………….. 1
1.3 Overview of the Study Area…………………………………………….. 3
1.4 Damages and Death Toll Experienced in Recent Past…………………… 4
1.5 Problem Statement……………………………………………………… 4
1.6 Objectives…………………………………………………………............ 5
1.7 Methodology……………………………………………………............ 5
1.8 Relevance to National Needs/ Research Outcome………………………... 6
1.9 Advantages……………………………………………………………. 6
1.10 Areas of Application………………………………………………... 7
1.11 Organization of the Thesis……………………………………............ 7

Chapter 2

Literature Review……………………………………………………….. 8-21

2.1 Rationale of the Chapter……………………………………………… 8
2.2 Background of Landslide Hazards in Pakistan…………………………….. 8
2.3 Triggering Mechanism for Landslide and Debris Flow……………………. 10
2.4 Factors Influencing Vulnerability to Landslides and Debris Flow Hazard… 10
2.5 History of Landslide Events……………...………………………………… 11
2.6 Landslide and Debris Flow Mitigation Measures (Some Best Practices of Different Countries)……………………………………………………….….... 12

2.6.1 Landslides in the Ethiopian Highlands and the Rift Margins……… 12
2.6.2 Ten years of Debris Flow Monitoring in the Moscardo Torrent (Italian Alps)…………………………………………………………………... 13
2.6.3 Mitigation of large Landslides and Debris Flows in Slovenia, Europe………………………………………………………………… 14
2.6.4 Debris Flow Monitoring and Warning Systems: A New Study Site in the Alps……………………………….…………………………….. 14
2.6.5 An Integrated Approach for Hazard Assessment and Mitigation of Debris Flows in the Italian Dolomite…... 15
2.6.6 Approach to Mountain Hazards in Tibet, China…………………… 15
2.6.7 Landslide Risk Assessment and Management: An Overview……… 15
2.6.8 Representative Rainfall Thresholds for Landslides in the Nepal Himalaya... 16
2.6.9 Landslide Hazards and Mitigation Measures at Gangtok, Sikkim Himalaya…………………………………………………….... …….. 17
2.6.10 Design, Development, and Deployment of a Wireless Sensor Network for Detection of Landslides, India……………………………… 17
2.6.11 The Impact of Landslide on Environment and Socio-economy: GIS based Study on Badulla District in Sri Lanka………………….......... 18
2.7 Community Based Interventions against Landslide and Debris Flow Hazard. 18
2.7.1 Enhancing Resilience to Landslide Disaster Risks through Rehabilitation of Slide Scars by Local Communities in Mt. Elgon, Uganda…………….. 18
2.7.2 Community-based Landslide Risk Reduction: A Review of a Red Cross Soil Bioengineering for Resilience Program in Honduras………………... 19
2.7.3 Using Multiple Vegetation Layers to Reduce the Risk of Rainfall-induced Landslides and Facilitate Post-Landslide Slope Rehabilitation…………... 20
2.7.4 Rehabilitation of a Debris Flow Prone Mountain Stream in Southwestern China- Strategies, Effects and Implications……………………………… 21
Chapter 3
Research Methodologies……………………………………………………... 22-28
3.1 Rationale of the Chapter…………………………………………………. 22
3.2 Data Collection Tools……………………………………………………. 22
3.2.1 Primary Data………………………………………………........ 22

3.2.1.1 Qualitative Key Informant Interviews………………………. 22

3.2.1.2 Quantitative Community Questionnaire…………………….. 23

3.2.2 Secondary Data………………………………………………… 23

3.3 Statistical Tools for Data Analysis……………………………………… 23

3.4 Research Design………………………………………………………. 23

3.5 The Survey Design Process…………………………………………… 25

3.6 Sampling………………………………………………………….…… 26

3.7 Pilot Survey……………………………………………………………. 27

3.7.1 Expert Opinion…………………………………………….…..... 27

3.7.2 Departmental Interviews……………………………………………… 27

3.8 Questionnaire Finalization……………………………………………….. 27

3.9 Full Scale Survey………………………………………………………… 28

Chapter 4

Data Analysis……………………………………………………………………. 29-72

4.1 Rationale of the Chapter……………………………………………….. 29

4.2 Demographic Information of the Respondents………………………..... 29

4.2.1 Gender of the Respondents……………………………………... 29

4.2.2 Age of the Respondents…………………………………………. 30

4.2.3 Education Background of the Respondents…………….…….. 31

4.3 Community Knowledge Regarding Landslide and Debris Flow Disasters in the Area………………………………………………………………. 32

4.3.1 Prior Knowledge about Landslide and Debris Flow Hazard……. 32

4.3.2 Experience of Past Landslide and Debris Flow Disasters………. 33

4.3.3 Common Damages as a Result of Landslide and Debris Flow Disaster……………………………………………………………….. 34

4.3.4 First Response in case of a Landslide/Debris Flow Event……... 35

4.3.5 District Disaster Management Authority Functioning……………. 36

4.3.6 Local Authorities Support in Times of Disaster…………….…. 37

4.3.7 Positive Change after DDMA Development…………………….. 38

4.4 Early Warning Information………………………………………………. 39

4.4.1 Provision of Warning/Information Regarding Landslide/Debris Flow Disaster……………………………………………………………….. 39

4.4.2 Early Warning System Known from Forefather's Time………… 40
4.4.3 Early Warning System Working………………………………….. 41
4.4.4 Information Dissemination with in the Community……………… 42
4.4.5 Landslide Monitoring and Warning System……………………... 43
4.4.6 Trust of Community in the Warnings issued…………………… 44
4.4.7 Beliefs in the Warnings……………………………………….. 45
4.4.8 Information Credibility, Reliability and Authenticity……………. 46
4.4.9 Community Preparation after Early Warning Information Dissemination……………………………………………………………. 47
4.5 Disaster Risk Reduction Measures………………………………………….. 48
4.5.1 DRR Measures…………………………………………………….. 48
4.5.2 Community Educated and Trained while dealing with Disasters. 49
4.5.3 Planned Relocation of Community to Safe Places……………… 50
4.5.4 Deforestation Surveillance System………………………………... 51
4.5.5 Afforestation under Khyber Pakhtukhwa Billion Tree Afforestation Project…………………………………………………………………. 52
4.5.6 Culverts and Water Channels…………………………………….. 53
4.5.7 Retaining Wall and Discharge Tunnel…………………………… 54
4.5.8 Soil and Water Conservation…………………………………….. 55
4.5.9 Slope Stabilization………………………………………………… 56
4.5.10 Engineering Applications i-e Check Dams, Dykes, Soil Bio-engineering Techniques, Biological Measures i-e Reforestation, And Social Measures i-e Reduction of Human Disturbance…………… 57
4.5.11 Debris Flow Breakers…………………………………………… 58
4.5.12 Drainage Mechanism…………………………………………….. 59
4.5.13 Training/Awareness Programs on Landslide and Debris Flow… 60
4.5.14 Participation of Community in Training/Awareness Initiatives… 61
4.5.15 Community Cooperation in Disaster Events……………………. 62
4.5.16 Hazard and Risk Assessment…………………………………… 63
4.5.17 Identification of High Risk Geographical Areas……………….. 64
4.5.18 Risk Sites Known to Community………………………………. 65
4.5.19 Development of Search and Rescue and Emergency Response Teams……………………………………………………………… 66

4.5.20 Regulations of New Settlements near Active Sites……………. 67
4.6 Semi Structure Interviews Of Concerned Departments……………………. 68
4.6.1 District Disaster Management Authority…………………………. 68
4.6.1.1 District Disaster Management Office (Dassu)………………….. 69
4.6.1.2 District Disaster Management Office (Pattan)………………….. 69
4.6.2 Pakistan Red Crescent Society (PRCS)…………………………… 70
4.6.3 Forest Department……………………………………………………. 71
4.6.4 Frontier Works Organization………………………………………. 71

Chapter 5

Findings, Conclusion and Recommendations………………………………… 73-75

5.1 Rationale of the Chapter…………………………………………………… 73
5.2 Findings of the Study……………………………………………………. 73
5.3 Conclusion………………………………………………………………… 74
5.4 Recommendations………………………………………………………… 74
References………………………………………………………………………… 76
Appendix……………………………………………………………………….. 81
Questionnaires………………………………………………………………………. 82
Semi-Structured Interviews…………………………..………………………… 86

LIST OF FIGURES

FIGURE	TITLE	PAGE NO.
1. 1	Map of Study Area……………………………………………………..	4
1. 2	Research Methodology Showing Different Steps Followed For Present Study…………………………………………………………………….	6
3. 1	Research Methodology……………………………………………….	25
3. 2	Research Design………………………………………………………	26
4.1	Gender of the Respondents………………………………………….	30
4. 2	Age of the Respondents……………………………………………..	31
4. 3	Education of the Respondents……………………………………….	32
4. 4	Prior Knowledge……………………………………………………..	33
4. 5	Experience of Disaster……………………………………………….	34
4. 6	Damages of Disasters………………………………………………..	35
4. 7	Community First Response…………………………………………..	36
4. 8	DDMA Functional/ Working…………………………………………	37
4. 9	Support from Local Authority………………………………………..	38
4. 10	Positive Change after DDMA Development…………………………	39
4. 11	Provision of Warning Information…………………………………...	40
4. 12	Early Warning System Known from forefather’s Time………………	41
4. 13	Early Warning System Working………………………………………	42
4. 14	Information Dissemination…………………………………………….	43
4. 15	Landslide Monitoring and Warning System…………………………..	44
4. 16	Trust of Community……………………………………………………	45
4. 17	Beliefs in the Warnings…………………………………………………	46
4. 18	Information Credibility, Reliability and Authenticity…………………..	47
4. 19	Community Preparation…………………………………………………	48
4. 20	DRR Measures…………………………………………………………..	49
4. 21	Community Educated and Trained……………………………………….	50
4. 22	Planned Relocation of Community………………………………………..	51
4. 23	Deforestation Surveillance system………………………………………	52
4. 24	Afforestation under Khyber Pakhtukhwa Billion Tree Afforestation Project	53
4. 25	Culverts and Water Channels………………………………………………..	54

4. 26	Retaining Wall and Discharge Tunnel……………………………………….	55
4. 27	Soil and Water Conservation…………………………………………………	56
4. 28	Slope Stabilization……………………………………………………………	57
4. 29	Engineering Applications, Soil Bio-Engineering Techniques, Biological Measures and Social Measures………………………………………………	58
4. 30	Debris Flow Breakers……………………………………………………….	59
4. 31	Drainage Mechanism………………………………………………………..	60
4. 32	Training/Awareness Programs………………………………………………	61
4. 33	Participation of Community…………………………………………………	62
4. 34	Community Cooperation in Disaster Events………………………………..	63
4. 35	Hazard and Risk Assessment………………………………………………..	64
4. 36	Identification of High Risk Geographical Areas…………………………….	65
4. 37	Risk Sites Known to Community……………………………………………	66
4. 38	Development of Search and Rescue and Emergency Response Teams……..	67
4. 39	Regulations of New Settlements near Active sites…………………………..	68

LIST OF TABLES		
TABLE	**TITLE**	**PAGE NO.**

2. 1	Historical Records of Landslides in Pakistan………………..........	12
4. 1	Gender of the Respondents…………………………………………	29
4. 2	Age of the Respondents……………………………………………..	30
4. 3	Education of the Respondents……………………………………….	31
4. 4	Prior Knowledge……………………………………………………..	32
4. 5	Experience of Disaster……………………………………………….	33
4. 6	Damages of Disasters………………………………………………..	34
4. 7	Community First Response…………………………………………..	35
4. 8	DDMA Functional/ Working…………………………………………	36
4. 9	Support from Local Authority………………………………………..	37
4. 10	Positive Change after DDMA Development…………………………	38
4. 11	Provision of Warning Information…………………………………...	39
4. 32	Early Warning System Known from forefather's Time………………	40
4. 13	Early Warning System Working………………………………………	41
4. 14	Information Dissemination…………………………………………….	42
4. 15	Landslide Monitoring and Warning System…………………………..	43
4. 16	Trust of Community……………………………………………………	44
4. 17	Beliefs in the Warnings………………………………………………..	45
4. 18	Information Credibility, Reliability and Authenticity…………………..	46
4. 49	Community Preparation……………………………………………….	47
4. 20	DRR Measures…………………………………………………………	48
4. 21	Community Educated and Trained………………………………………	49
4. 22	Planned Relocation of Community……………………………………..	50
4. 23	Deforestation Surveillance system………………………………………	51
4. 24	Afforestation under Khyber Pakhtukhwa Billion Tree Afforestation Project..	52
4. 25	Culverts and Water Channels………………………………………………..	53
4. 26	Retaining Wall and Discharge Tunnel……………………………………….	54
4. 27	Soil and Water Conservation………………………………………………….	55
4. 28	Slope Stabilization…………………………………………………………….	56

4. 29 Engineering Applications, Soil Bio-Engineering Techniques, Biological Measures and Social Measures………………………………………………… 57
4. 30 Debris Flow Breakers………………………………………………………. 58
4. 31 Drainage Mechanism……………………………………………………….. 59
4. 32 Training/Awareness Programs……………………………………………… 60
4. 33 Participation of Community………………………………………………… 61
4. 34 Community Cooperation in Disaster Events………………………………… 62
4. 35 Hazard and Risk Assessment……………………………………………….. 63
4. 36 Identification of High Risk Geographical Areas……………………………. 64
4. 37 Risk Sites Known to Community…………………………………………… 65
4. 38 Development of Search and Rescue and Emergency Response Teams…….. 66
4. 39 Regulations of New Settlements near Active sites………………………….. 67

LIST OF ABBREVIATION

DDMA	District Disaster Management Authority
PDMA	Provincial Disaster Management Authority
NDMA	National Disaster Management Authority
PDMC	Provincial Disaster Management Committee
NDMC	National Disaster Management Committee
PRCS	Pakistan Red Crescent Authority
CPEC	China Pakistan Economic Corridor
KKH	Karakoram Highway
DDMU	District Disaster Management Unit
DDMO	District Disaster Management Officer
DEOC	District Emergency Operation Centre
PEOC	Provincial Emergency Operation Centre
NEOC	National Emergency Operation Centre
CBO	Community Based Organization
DDRT	District Disaster Response Teams
TDRT	Tehsil Disaster Response Teams
CDRT	Community Disaster Response Teams
DC	Deputy Commissioner
MHVRA	Multi Hazard Vulnerability and Risk Assessment
DRR	Disaster Risk Reduction
KPK	Khyber Pakhtunkhwa
DHPP	Dasu Hydro Power Project
FWO	Frontier Works Organization
FATA	Federally Administered Tribal Areas
MAP	Mean Annual Precipitation
GIS	Geographical Information System
EIA	Environmental Impact Assessment
HRC/SRC	Honduran and Swiss Red Cross
SPSS	Statistical Package for Social Sciences
EWS	Early Warning System

BTAP	Billion Tree Afforestation Project
NFI	Non Food Items
TMA	Tehsil Municipal Administration

ABSTRACT

Landslide and debris flow are the most prevalent and frequently occurring hazards in northern region of Pakistan. These complex hazards can cause substantial adverse social and economic impacts. Landslide and debris flow are a ubiquitous hazard in mountainous environment with slopes, incurring human fatalities in rural settlements along transport corridors. Their frequencies and impacts, such as fatalities, injuries and damage to properties have been accelerating over the years. This study is focused to examine the community resilience to landslide and debris flow hazards in Kohistan district along main transportation corridor (Karakoram Highway). The response of local people about the community level of resilience against landslides and debris flow in the area was assessed through a questionnaire based survey. Key informant interviews were conducted from the representatives of different departments in order to evaluate their role in landslide and debris flow hazard mitigation. The data analysis was done through using a comprehensive software SPSS (Statistical Package for Social Sciences). The analysis of the data identified that resilience capacity of local population against landslide and debris flow was low and role of concerned departments were not satisfactory. There was no proper mechanism of monitoring and early warning information in place, no adequate structural disaster risk reduction measures was developed, trainings and mock drills were neglected, coordination among departments was missing and communication of information with communities were not practiced. Based on the analysis of this study, several measures are recommended to enhance the resilience capacity of communities and concerned district departments which may be applicable at national level. Disaster Risk Reduction measures and Multi Hazard Vulnerability and Risk Assessment (MHVRA) should be developed. Specialized DRR expertise/ human resource, funds, building infrastructure and equipment should be provided to District Disaster Management Units. Development projects must ensure soil and rock conservation mainly in areas prone to landslide and debris flow risks. Economic and developmental projects should be designed in accordance to disaster management policies with proper collaboration between departments for local level implementation.

Chapter 1

INTRODUCTION

1.1 RATIONALE OF THE CHAPTER

This chapter highlights the reason for conducting research on landslide and debris flow risk reduction on main Karakoram Highway. It covers problem statement, relevance to national needs, advantages and areas of application for better implementation of risk reduction measures against landslide/debris flow disaster.

1.2 BACKGROUND

Landslides and debris flow are common geological phenomena in different regions of the globe and refers to a wide-ranging process that results in the sensible downward and outward movement of rocks, earth, and debris under the force of gravitation (Fowze, Bergado, Soralump, Voottipreux, & Dechasakulsom, 2012).

Landslide is a main hazard, accounts every year for massive developmental losses. Landslide is define as the shift of rocks, debris or earth down a slope can be trigger by different extrinsic stimuli, such like heavy rainfalls, seismic shakings, changes in water level, storm waves or fast erosions of stream water that induce a hasty rise in shear stress or decrease in shear strength of slope forming material. Beside this, as developmental activities expand into unbalanced mountain slopes under the pressure of population rise and urbanization, deforestation practices or excavations of rocks for transportation routes and infrastructure etc., have become consequential drivers for occurrence of landslides (Dai, Lee, & Ngai, 2002).

Landslide are both a natural and human-induced phenomena in the mountainous terrains, creating alluvial fans and leveling out steep terrains that have been converted into productive terraces over times by population (Karen et al, 2012). Rainfall is recognized as one of the most important triggering factor for landslide. Regardless of various studies, the rainfall effects on triggering landslides remains poorly understood (Campbell, 1974; Pierson, 1980; Buchanan and Savigny, 1990; Larson and Simon, 1993; Montgomery and Dietrich, 1994; Crozier and Glade, 1999; Wieczoreck et al, 2000)). This is due to complexity, variability (in space and time) and scale dependency of factors controlling slope instability. Among all the landslide types (Varnes, 1978), shallow landslide, such as soil slip and debris flow, exhibit a strict reliance, both temporal and spatial on rainfalls. Furthermore, these types of shallow landslides are regionally diffused phenomena. Shallow landslide shows a high sensitivity to both spatial and temporal distribution of rainfalls as well as to rainfalls intensity, rainfalls duration and amount of antecedent precipitations (Crosta & Frattini, 2001).

Landslide and debris flow are main drivers in causing natural disaster and societal hazards in hilly regions over the globe. The bedrock geology, lithology, geotechnical properties, rainfalls, ground water condition and land use condition have interrelationships in landslides occurring. Analysing the relationships between landslide and the various factor causing landslide not only put a glance to understand landslides mechanism, but also can form a base for forecasting future landslide and evaluation of these hazards. In area with the similar geo-technical condition, researcher usually makes two basic suppositions. On the one hand, landslide will occur in the same geological, geomorphological, hydrogeological and climatic conditions as occurred in the past. On the other hand, the properties and types of landslide activities will also be the same (Hutchinson 1995; Aleotti and Chowdhury 1999). Hence, the investigation of the mechanisms and characteristics of past landslides are key reference for evaluating the future landslides in its adjoining or geotechnical same areas (Wang, Esaki, Xie, & Qiu, 2006). Rainfall triggered landslide presents significant hazards to unprepared population in tropical developing countries (Holcombe & Anderson, 2010). People living near to these hazardous sites are exposed to higher risk both in terms of physical and financial losses. Frequent events enhance the socio-economic vulnerabilities of the people living nearby by blocking the roads, pathways, rivers, harm to agriculture system, property and disruption of livelihoods. The fall of debris resulting from a landslide event also has catastrophic impacts for population living below.

The Northern areas of Pakistan are commonly exposed to landslide and debris flow risk. Kohistan District specifically has remained highly vulnerable to the risks of these hazards over the years. The unstable rugged terrain and unchecked deforestation has further aggravated the situation, leading to high disaster frequency. The population live in this remote area has not adopted any counter measures in regard of debris flow and landslide mainly because of lack of awareness and proper administrative assistance. The people living near to these hazardous sites are exposed to higher risk both in terms of physical and financial losses. Frequent events enhance the socio-economic vulnerabilities of the people living nearby by blocking the roads, pathways, rivers, harm to agriculture system, property and disruption of livelihoods. The fall of debris resulting from a landslide event also has catastrophic impacts for population living below.

Since Kohistan is one of the mountainous districts along the Karakoram Highway which is a major trade route of Pakistan, there is an urgent need to work out community based interventions for reducing the risk of landsides and resulting debris flow. Due to its remote locality and lack of attention, the high hazard area has remained deprived of effective mechanism of disaster risk reduction.

1.3 OVERVIEW OF THE STUDY AREA

Kohistan lies between 34º 54´ and 35º 52´ north latitude and 72º 43´ and 73º 57´ east longitude. It is bounded on the north and northeast by Ghizer and Diamer districts of northern regions, on the southeast by Mansehra district, on the south by Battagram district and on the west by Shangla and Swat districts of KPK. The name Kohistan literally means "Land of Mountains". In fact there is hardly any plain area. It could be correctly depicted as all mountains dotted with land. The Indus river cuts through the heart of Kohistan from start to end and divides it into two parts. The whole Kohistan district is now divided into three districts namely, Kohistan Lower, Kolai Palas Kohistan and Upper Kohistan.

The study was carried out along a transportation corridor of a 55 km section of the Karakoram Highway, alongside the River Indus. The types of element at risks present along the highway are local population and road passengers. The road is used for goods transportation to northern parts of Pakistan from rest of the country. This route is also used for major trade between China and Pakistan. The great number of tourist vehicles drive on this route in tourism season, which further enhances its importance.

During monsoon rainfall and in winter season, it is mainly blocked by falling of rocks and debris and sometimes heavy land sliding occurs which stranded thousands of passengers travelling between Gilgit and Rawalpindi for several days.

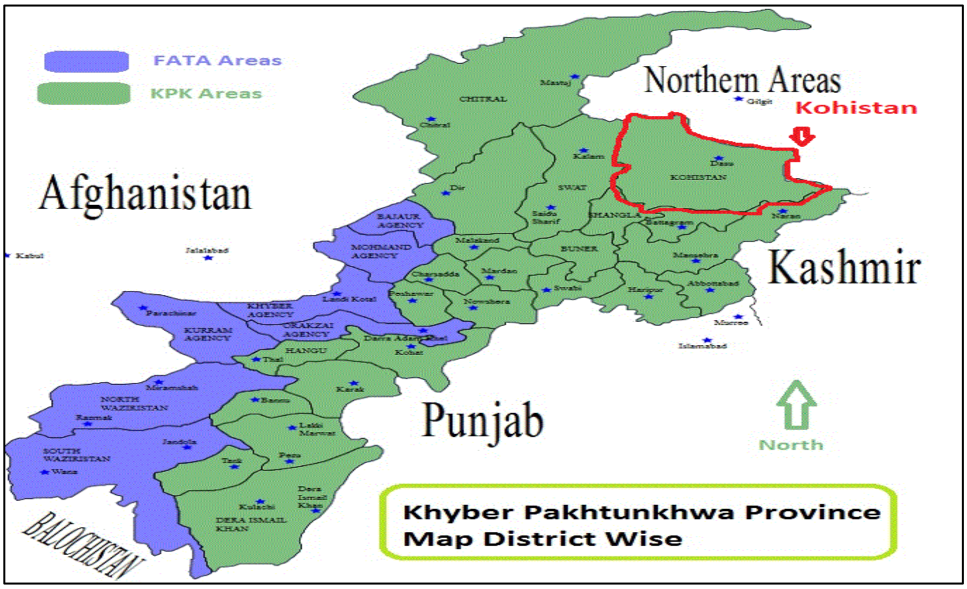

Figure 1.1 Map of Study Area (Source: Google Maps)

1.4 DAMAGES AND DEATH TOLL EXPERIENCED IN RECENT PAST

In recent past, eight laborers working on Dasu hydropower project were buried alive after their vehicle was struck by a huge landslide in upper Kohistan area (Dawn, 2019). Another landslide activity at Shatial area of Kohistan on main KKH stranded thousands of passengers travelling between Gilgit and Rawalpindi for several hours (Times of Islamabad, 2019). In April 2016, the torrential rains led to storm and triggered land sliding in Kohistan district which engulfed 25 people, including 13 women with a week-long blockage of KKH (Sost Today, 2016). With the expected trade influx along the KKH in near future, it is mandatory to pinpoint risk zones of landslides and debris flows to work out feasible solutions for potential future disasters.

1.5 PROBLEM STATEMENT

Debris flow and landslides have remained the most devastating hazards that frequently turn into disasters in the Kohistan area. These disasters have resulted in huge losses for communities, disrupting their lifeline (i.e. KKH) and caused deterioration of their socio-economic activities. With the increasing frequency of these events and the expected trade influx along the KKH in near future, it is critically substantial to evaluate the existing DRR mechanism in the area and work out feasible and sustainable intervention utilizing local capacities and communities.

1.6 OBJECTIVES

- To evaluate existing mitigation measures at the community and govt. level.
- To propose guidelines for building resilience of local communities.

1.7 METHODOLOGY

The mode of data collection was through Questionnaires and Semi Structure Interviews. Representatives from different walks of life were asked open ended questions in line with the research objectives. 200 number of Questionnaires data were gathered from the community people. A departmental interview was taken from District Disaster Management Authority (Dasu and Pattan offices), Pakistan Red Crescent Society Kohistan Branch, Forest Department and Frontier Works Organization to get a brief overview of the post disaster measures till to date. Random sampling was carried on to decide the number of respondents.

Broadly, the questions revolved around the following aspects.

- What is the frequency and extent of Landslide and Debris Flow Hazard
- What mitigation measures been taken to minimize the risk in the area
- What are the possible remedial measures for mitigation of the risk

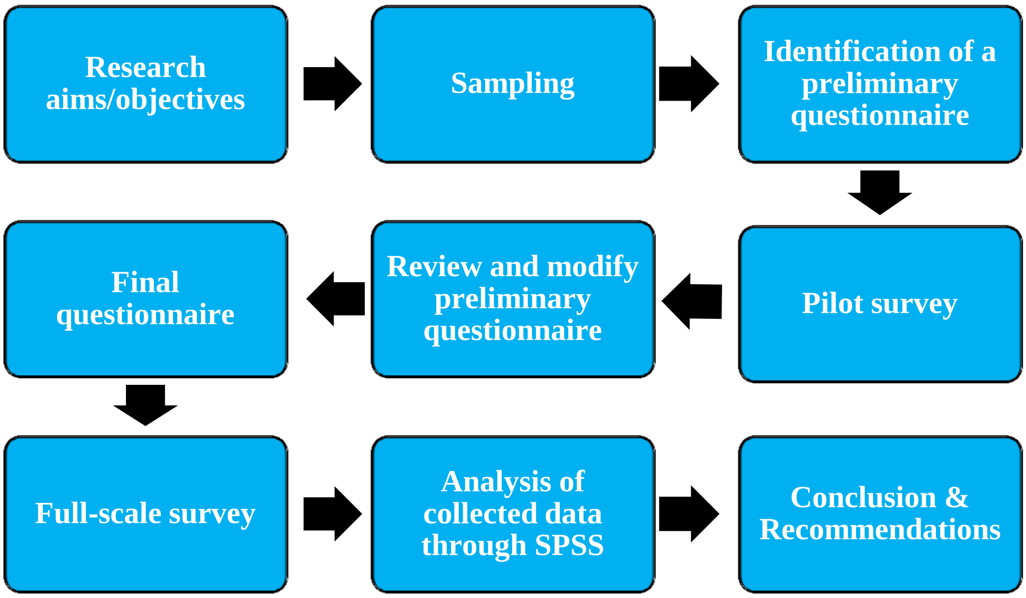

Figure 1.2 Research Methodology Showing Different Steps Followed For Present Study

1.8 RELEVANCE TO NATIONAL NEEDS/ RESEARCH OUTCOME

The Karakoram Highway holds a significant position in contributing towards national economic growth and development. Since disaster such as landslide and debris flows are among the key challenges along the route. These pose a continuous threat to the functionality of this trade highway. With increasing frequency and lack of effective management or risk reduction intervention at district level not only the KKH but the socio-economic activities of mountain communities remain continuously at stake. This study will help in working out feasible corrective measures and enhancing the capacity of communities against these disasters to ensure minimum losses and disruption of the highway for the broader national interest.

1.9 ADVANTAGES

This research has vast advantages for all stakeholders involved like community people, road traffic and CPEC project. The outcome of this research holds a great significance by formulating proper preparedness, mitigation and prevention measures against landslide and debris flow hazards along the Karakoram Highway. It will also ensure the sustainability of the CPEC project which is a huge investment in the area. It will give a baseline for all the stakeholders in formulation of monitoring and mitigation plans to reduce the adversities.

1.10 AREAS OF APPLICATION

- District Disaster Management Authority (DDMA)
- Provincial Disaster Management Authority (PDMA)
- National Disaster Management Authority (NDMA)
- Rescue 1122
- District Administration
- Frontier Works Organization (FWO)
- Forest Department
- Community

1.11 ORGANIZATION OF THE THESIS

Chapter 1 introduces the thesis to readers with an insight of the study area, hazard profile of the region, objectives of the study, advantages of current research and its need for national to grass root level. It also enlists potential areas of application of this research.

Chapter 2 comprises of a review of all the literature consulted for this research. This includes research papers, newspaper articles, assessment reports and work of numerous workers who have worked on landslide and debris flow hazards and community based approaches in the past, local, regional and international practices for risk reduction and mitigation of landslides and debris adopted by various mountain communities.

Chapter 3 states the methodologies opted for this research. It includes the research design and techniques used for calculation of sample sizes, data analysis and its interpretation.

Chapter 4 analyzes the collected data through using SPSS and obtains result. It also elaborates the output of research.

Chapter 5 depicts findings and conclusions drawn from the study and suggests feasible recommendations for mitigation of adverse effects from future disasters in the area.

Chapter 2

LITERATURE REVIEW

2.1 RATIONALE OF THE CHAPTER

This chapter describes the detail of literature studied for assessment of mitigation measures developed and implemented in different mountainous regions across the globe. Literature review assists in determination of applicable mitigation and preparation measures that can be adopted to tackle the risk.

2.2 BACKGROUND OF LANDSLIDES HAZARD IN PAKISTAN

Landslide disasters are very common and frequent phenomenon across the hilly areas of Pakistan (Niederer & Schaffiner, 1988). Geologically, Himalayan Mountains are composed of the immature and the most dominant mountains systems on the earth. They consist of the worst landslide impacted areas of Pakistan (Kazmi & Jan, 1997). It has been surveyed that 30 percent of the global landslide occurs in Himalaya (Khan, Landslide hazard and policy response in Pakistan: a case study of Murree, Pakistan, 2000). After the 2005 Kashmir earthquake, 1293 landslide activities were spotted at 174 different places only in Balakot (Owen, 2008).

Landslides depend on various numbers of accompanying agents like slope gradients, lithology, lands covers, morphology, drainage areas and the ground-water settings that bring landslides vulnerability (Hughes, 1982). The landslide has close relationships to the slopes gradients and is a considerable element in activating landslide activities (Kamp, 2010). The landslides density amplified with rise in slope angle (Msilimba, 2010). Similarly, the landslides vulnerability differs from place to place but the rainfalls triggered landslide occurs very frequently (Li, 2010) mainly in region characterized by torrential seasonal precipitations. Many disastrous landslide caused by earthquake have been analysed across the globe (Kamp, 2010). Moreover, lithology is broadly considered as one of the most crucial factor that affect landslide (Clerici, 2010) and subdue to a preliminary escalating force such as rainfalls or seismic shaking for their happenings (Wan, 2010). Moreover, some human factors also induce landslide like land use and infrastructure development (Wan, 2010). The forests are protecting nature from landslides (Kamp, 2010). The anthropogenic activities may disturb the slope line and make it unbalanced if it is near to a sample point (Wan, 2010).

During precipitation in Pakistan, landslide occurs mainly along the transportation routes built in hilly terrains (Khan & Atta-ur-Rahman, 2006). The timber cutting activities have also worsens the problems of land sliding in mountainous regions of north and northwest sides of Pakistan (Khan, 1994). Though no specified and organized study has been attempted to finds the limit of problems. Pakistan is recently paying special attention to the subject matter of landslide. The Federal Forests Divisions, Highways and Mining Divisions are conducting researches and executing many initiatives to mitigate landslides hazard through engineering and afforestation measure. Though, no adequate administrative set up exist either at country or province level for implementation, monitoring and evaluating project concerning the risk reduction of landslides hazard and disaster response.

The challenge of mass movement ranges from debris and rocks fall to substantial landslide, avalanche, soils creeping and muds flows (Kamp, 2010). It is a regular and ongoing geomorphological hazard disrupting the daily life activities of communities residing in the sloppy terrains of Pakistan (Khan & Atta-ur-Rahman, 2006). The process of slopes failures, among the geologically immature, ragged and jagged foothills of the Himalayas have serious negative impacts, both directly and indirectly, on the lifestyle of communities residing in these areas historically. Landslide activities in these regions repeatedly cause deaths, damages of housing, highways, crop and many other belongings. These destructive processes in the mountainous environments have widespread adverse effects also expanding to the plains environment (Owen, 2008).

The direct effects of slopes failures and landslide in the mountains of Pakistan include fatalities, injuries, the damages of housing infrastructure and various other damages. It includes the periodic disturbance of transportation routes and other lifelines, pipeline, irrigations channel, water supply systems and whole human settlement. The 1980 International Karakoram Expedition, identified 335 various forms of, size and periods of landslide activities in one of their comprehensive survey of a 139 kilometer long strip along the Karakoram Highway between Gilgit and Gulmit (Miller, 1984). Besides the fast flow and abrupt movement that leads to the crash of buildings, crawling movement such as extensive soil creeping occurs in the locality, which constantly demolishes housing infrastructure and other buildings from their foundations (Khan, 1992).

2.3 TRIGGERING MECHANISM FOR LANDSLIDE AND DEBRIS FLOW

Although the major triggering agents for landslide and debris flow are rainfall, transportation infrastructure and clear-cuttings in hilly areas also contributing in escalation of these hazards (Fowze, Bergado, Soralump, Voottipreux, & Dechasakulsom, 2012). Causal factors are precipitation and earthquake and Preparatory factors are slope geometry, soil and geology, slope hydrology, and vegetation. Anthropogenic influences are surface water, groundwater level, and slope angle, load (buildings) and vegetation (Holcombe & Anderson, 2010).

Semiarid-subtropical climate, annual precipitation rate, mining in the area, demolished bushy forests, deforestation, increased gully erosion, loss of vegetation, aged and extended structural faults zones comprised of secondary fault, degraded ecosystem (Yu, Huang, Wang, Brierley, & Zhang, 2012).

The article highlights that enormous seismic generated landslide takes place on slope areas along highway and river. Under-cutting of slope by rivers erosions and anthropogenic exercises such as construction of highway, tree cutting, terracing, and agriculture practices are possibly the main reasons for these secondary failures (Khattak, Owen, Kamp, & Harp, 2010).

2.4 FACTORS INFLUENCING VULNERABILITY TO LANDSLIDES AND DERIS FLOW HAZARDS

The primary studies show that there are various elements that have aggravated the progression of vulnerability in the region. Few of the most significant elements include;

- (i) Limited access to political power, decision making and resources
- (ii) Unsecured livelihood
- (iii) Environmental degradations
- (iv) Globalized trade and unequal exchange of benefits
- (v) Shortsighted developmental plans and ineffectiveness of the state approach to disaster risk reduction

(vi) Negligence of indigenous knowledge and other coping capacities

(vii) Coexistence of collective hazard (Santha & Sreedharan, 2010).

By using the collected data to get the quantitative and qualitative information about the causes of landslide (Kaleela & Reezab, 2017) argue that the physical factors what reasons for the landslide are topographic form, rock type, barrier in water flow, natural current, soil erosion and natural vegetation cover. The human factors of landslide are improper land use, improper infrastructure, deforestation, Chena cultivation, transport development.

2.5 HISTORY OF LANDSLIDE EVENTS

Landslides are a common hazard on Earth (Solana & Kilburn, 2003). In 2003 alone, the total reported deaths by landslides were about 18,200 throughout the world (Nadim, Kjekstad, & Peduzzi, 2006). Landslide disaster may affect small areas but often lead to severe financial losses and human casualties (Ho, Shaw, & Lin, 2008). Landslide disasters have extensively affects life, live stocks, infrastructure, life lines, houses and agriculture land across the globe (Neuhäuser, Papathoma-Köhle, & Ratzinger, 2007). Like rest of the world, Pakistan also experienced with landslide disasters, especially in the mountainous regions of the country (Table 2.1). Ones such landslides prone sites in the region is the Pakistani Himalaya regions (Khattak, Owen, Kamp, & Harp, 2010). Kohistan district is one of the worsts landslide impacted region of Himalaya of Pakistan. In monsoon seasons i-e from July to August, it receive highest average annual rainfall of 1640 mm. Therefore, landslide frequently occurs during this season. Mountains in Kohistan are composed of frangible rocks, inter-bedded with soft calcareous shale and are therefore exposed to landslide disaster. Besides fragility of the natural environment, human unsustainable practices involving illegitimate land use and deforestation have also contributed for occurrence of landslide activities in the region.

Table 2.1 Historical Records of Landslide Disasters in Pakistan

Year	Number of lives lost	Location
03 November, 2017	08	Bajuar Agency (EX-FATA), KP
04 January, 2010	20	Attabad, Gilgit Baltistan
March, 2007	80	Dir, KP
January, 2007	20	Kotli Kashmir
September, 2006	04	Muree Hills, KP
July, 2006	29	Ghael Village (Kalam, KP)
May, 2003	12	UC Ranolia Kohistan, KP
July, 2001	16	Karachi, Hyderabad, Sukkhur, Sindh
July, 2001	15	Chitha Khatha, Kaghan KP

Source: (EM-DAT. The OFDA/CRED International Disaster Database)

2.6 LANDSLIDE AND DEBRIS FLOW MITIGATION MEASURES (SOME BEST PRACTICES OF DIFFERENT COUNTRIES)

2.6.1 Landslide in the Ethiopian Highland and the Rift Margin

This study highlights clear example of human vulnerabilities to landslides in many areas of the Ethiopian highland. The population growth is posing ever increasing demands for new lands for settlements, infrastructures and agricultures. Also the needs for power supply and construction material are mostly fulfilled at the expense of environment. Slope movement induced by gravity adversely impact cultivated lands, infrastructure and human settlement, and are resulting in hurdles in the social and economic development of Ethiopia. In addition to the naturally vulnerable landslide sites, owing to their geological and hydrological condition, human behavior has played a significant role in increasing lands degradations. Besides the destabilizing effect of spring water and seasonal rainfalls, poor standard buildings constructed on the slope without adequate site inspection and using low materials types and quality, has worsen the situations. Damage to infrastructure caused by slope instability problems in the Blue Nile gorge, is basically due to the presence of soft sedimentary levels like shale and marl. As the community grows, landslides risks will also multiply unless proper risk reduction practices are followed during developmental projects. Hence, for successful design and location of strong infrastructure, settlement, and other developmental activities, it is necessary to undertake assessments and control landslides instability risk. These risk reduction practices involve; proper drainage mechanism (rerouting springs and rain water) out of the slope to control concentrated infiltration of water; gully recovering and control; retaining wall, especially along some road side; afforestation; prohibiting constructions on unbalanced slope or at the feet of steep rocky slope, in case of shallow movement. Expensive works to stabilize landslide is only recommended where essential. On the far side, proper place inspections for infrastructure building, transfer of at risk settlement, precise geological control work, and well-designed awareness initiatives are highly commended measure in the Ethiopian contexts (Abebe, Dramis, Fubelli, Umer, & Asrat, 2010).

2.6.2 Ten years of Debris Flow Monitoring in the Moscardo Torrent (Italian Alps)

A monitoring systems comprising of two ultrasonic sensors and a rain gauge was set up in the Moscardo Torrent in 1989. The rain gauge was set near to the basin junction at a height of 1520 meter, which is about the average catchment altitude. Two ultrasonic sensors were set up in mid fan area on a channel stretches 300 meter long, with an average slope of 10 percent. In 1995, the new one ultrasonic sensor substituted the old and a third ultrasonic sensor was deployed further upstream, stretching the total length of the monitored channel reach to 370 meter. A fixed video camera was placed close to the mean of the three ultrasonic sensors and a network of four seismic detectors was installed about 1 kilo meter upstream from the ultrasonic gauging station. Video recording is generated by means of software, which ascertains rapid changes in stage values recorded by the upstream ultrasonic gauge. In 1997, a second rain gauge was also positioned in the center of the basin and two new seismic sensors were installed on the fan close to the intermediate ultrasonic gauge. Debris Flow Records: (Rainfall data, Ultrasonic data, seismic data, Video recorded data). Two debris flow events that took place in 1989 are not included in this study because the logging interval (1 stage value per minute) did not ensure sufficient accuracy. From 1990 to 1998, 15 debris flow events occurred; 14 of which were recorded by the installed gauges; for one event (June 23, 1998), only the rainfall and time of occurrence are known (Marchi, Arattano, & Deganutti, 2002).

2.6.3 Mitigation of Large Landslide and Debris Flow in Slovenia, Europe

Main parts of Slovenia are exposed to extreme natural hazard, such as earthquake, fire, landslide, flood and rock fall, assumes from this paper. The number of disasters increased in the last ten years, debiting state budget and budgets of over 200 local communities. These are in most cases unable to cover economic losses, as well as organizing and financing mitigations of large natural disaster (drought, flood, large landslide). It is therefore legally regulated that mitigations in such cases goes to the debit of the state. Possible measure on larger landslide before their final mitigations can be separated into intervention measure (removals of landslides or debris flow masses mechanically, evacuations of residents on temporary basis, and observation on daily basis) in case of emergency (torrential rainfalls, larger landslides displacement) and final mitigations measure. These are various practices;

- Fields and laboratories investigation (aero photogrammetry, geological map, borehole, inclinometer, geophysical method, infiltration test, discharge measurement, material property)
- Modeling (slopes stability, debris flow, mudflow)
- Future hazards assessments (possible scenario)
- Mitigations measure (proposing solution, project documentations, constructions)
- Post mitigations observation (survey and remote sensing, warnings system)

In Slovenia, applicable cases with mitigations of larger landslide hazards unveils that only a realistic and perceptive coordination, inter-disciplinary approaches and proper economic supports may leads to flourishing larger landslides mitigations practices (Mikoš & Majes, 2014).

2.6.4 Debris Flows Monitoring and Warnings System: A New Study Sites in the Alps

In order to stop, divert or “flush” debris flows from at risk localities, physical measures like check dams have been constructed from decade. However, such practices face some managerial issues. Indeed, they require a huge amount of financial resources to construct and to maintains (e.g. sediments removal and restoration of damaged works) and they may have negative effects on the continuity of sediment fluxes through the drainage systems. In addition, in many cases they cannot eliminate altogether the debris flow risks, i.e. a residual risk is still present after their implementation. Therefore, it is now a day recognized that both structural and nonstructural measures are necessary in most scenarios to tackle debris flows risk. Nonstructural measure aims to minimize the vulnerabilities of a specific area to debris flow phenomena, by minimizing either on permanent basis (land use planning) or on temporary basis (warnings system) the possibility that human and their belonging might be struck by a debris flow (Comiti, Macconi, & Marchi, 2010).

2.6.5 An Integrated Approach for Hazard Assessment and Mitigation of Debris Flows in the Italian Dolomites

It has been revealed from the study that the Belluno Civil Engineering Board built two retaining walls with a captive deposit area capable to catch up to 11,000 m^3. Furthermore a discharge tunnel under the country roadway for diversion of debris flow track was also constructed. More over the Municipality department transfer at risk communities to safer locations (Pasuto & Soldati, 2004).

2.6.6 Approaches to Mountains Hazards in Tibet, China

The scientific research are to be strengthen between the neighboring countries in the future, planning for mitigation measures in the potential dangerous zones such as forbidding human activities and construction, people and infrastructure in the most active sites must be relocated. The effective early warning and forecasting mechanism for hazard reduction like weather station, hydrometric station, and disaster observation station in disaster prone areas are to be established. Unnecessary human activities are to be forbidden in the mountainous regions for conservations of soils and water and safeguard of forests and grassland. Local people and govt. officials are to be trained about the mitigation measures to reduce the hazards (Dongtao, Jianjun, Peng, & Ruren, 2004).

2.6.7 Landslides Risks Assessments and Management

For landslides risks to be managed, following measures are to be considered in this article, like planning control in which new developments in landslide prone areas are discouraged or regulated by the local governments which is the most economical and feasible means to minimize the losses. Engineering solutions are the most direct but expensive strategies for landslides risks reduction. Two common approaches are attainable for reducing landslides risks. One is compaction of the underlying unsteady slopes to regulate initiations of landslide, and the other is to control the landslides movements. Communities are required to accept the risks from given landslides under the conditions that the risk is finely understood. The choosing of this option is based on consideration that the risk from landslide is offset against the benefit which the community gets in the particular location, or that risk from landslide is bearable. Potential unbalanced slope can be monitored in order to warn the highly impacted population, and can be evacuated when the situation got worse. For particular landslide or potentially active slope of enormous size that stability work and engineering solution were not only impractical but would also not be cost-effective in relations to the properties at risk, monitoring and landslides warnings would be alternate options in reducing landslides risks (Dai, Lee, & Ngai, 2002).

2.6.8 Representative Rainfalls Thresholds for Landslides in the Nepal Himalaya

A 55 years study records of landslide activities and rainfalls in the Himalaya has revealed that a wide-ranging rainfalls duration (5 h to 90 days) cause many landslide events. On an average, a rainfall of 10 h or less require rainfall intensity in excess of 12 mm h^{-1} to triggers failures, but rainfall duration of 100 h or longer with an average intensity of 2 mm h^{-1} can also triggers landslide in the Himalaya. Furthermore, in the daily rainfalls scenarios, this study shows that when daily rainfalls amount exceed 144 mm, there is always risks of landslide in Himalayan slope. The landslides thresholds relations indicate that in Himalaya, three times more rainfalls needed to triggers landslide in short span than the rainfalls amounts needed to triggers landslide worldwide. Similarly, the difference of rainfalls thresholds in tropical monsoons and other climate is less important when rainfall intensity of 100 h is considered. The comparisons between the intensity durations threshold and the normal threshold of Himalaya show small variations. The normal trends of the thresholds line remain the same, and the patterns of the threshold are also preserved. Though, the normal intensity duration thresholds could not well represents duration longer than 400 h. The thresholds relations indicate that for rainfalls event of shorter durations, such as less than 10 h, a normal rainfalls intensity of 0.28 per hour (i.e. 28% of MAP) is needed to triggers slopes failures, whereas a normal rainfalls intensity of less than 0.07 per hour (7% of MAP) may sufficiently causes land sliding when continuous rainfalls durations exceed 100 h. Likewise, for a one day period, a rainfalls amount equals to 17% of MAP is needed for the initiations of land sliding.

It is also obvious that the antecedent rainfalls play significant roles in landslides triggering effects in the Himalaya (Dahal & Hasegawa, 2008).

2.6.9 Landslides Hazard and Mitigations Measure at Gangtok, Sikkim Himalaya

Landslide regularly occurs in the Himalayan State of Sikkim, India. This is because of rainfalls high intensities that not only contribute to fast erosions and weathering of the rocks, but also increase groundwater level that cause reductions in the balancing of natural slope. These factors, combined with the increasing human activities related to cities developments, have contributed to escalated unstable slopes in the area. The geotechnical investigation performed in the impacted area indicates that both the overlying soils and the discrete joints surface in the bedrocks have dislocated during the landslides. Sliding along the discontinuities has occurred because of high pores water pressure along the joint. Both smooth and rough joint are affected by elevated water pressure results from high intensity rainfalls. Sliding of the overlying soils are linked with the saturation of soils pores and with formation of shallow and deep subsurface flow that create pores water pressure in the materials that forms the slope. Many mitigations measure have been examined for monitoring and reducing the landslides hazard. Monitoring strategies includes pore water pressure measurement using piezometer and measurement of ground movements by means of triangulation using movement pillar. Measure for reducing the hazard includes construction and maintenance of drainage canal lined with ductile material, growing of vegetation, construction of tunnel, and regulations of human activities in the affected regions (Bhasin, Grimstad, & Larsen, 2002).

2.6.10 Design, Development and Deployment of a Wireless Sensor Network for Detection of Landslide, India

Wireless sensor networks are the most effective technique for real-time monitoring of areas that are susceptible to disaster events. This network includes the experiment of design, development and deployment of a wireless sensor network for landslides detections. It has the ability to deliver real times data through the Internet and also to issue warning ahead of time using the innovative three level warnings system that were developed as part of this work. The systems incorporate energy efficient data collection method, fault tolerant clustering approach, and thresholds based data aggregation technique. Since three years, huge amount of data has been collected, delivering a better understandings of landslides scenario, and is prepared to give warnings about any significant future landslides activity. The systems have been testified by issuing real warnings to the local communities during the torrential rainfall in the July 2009 monsoon seasons. This system is applicable to other landslides prone sites and also can be used for floods, avalanches, and water quality monitoring with minor modification (Ramesh, 2014).

2.6.11 The Impact of Landslide on Environment and Socio-economy: GIS based Study on Badulla District in Sri Lanka

(Kaleela & Reezab, 2017) Proposed solutions to reduce the landslides issue i-e Identify the landslide area, collecting the reports of infrastructure and precautions of landslide are supporting to reduce the effect and can move shift the residents to safer places. When shows the maps using GIS technologies for this landslide area helping to shift the population to safer places. By this map can identify the landslide zone, safe zone, exiting way, etc. and also can be done the awareness programmes using these maps. Depth roots plants should be planted in this area to capture the soil and rock that will prevent the slide. Reservoirs must be built after doing the geological examination and geomorphological examination. It should do after getting EIA approval. Using the screed concrete in the base of mountains and making the Gabion walls of the width and height of mountains help to prevent the slide. This method called Geo textile Gabion walls. Encourage the people to do the Terrace / Furrows Farming system.

2.7 COMMUNITY BASED INTERVENTIONS AGAINST LANDSLIDE AND DEBRIS FLOW HAZARD (SOME BEST PRACTICES)

2.7.1 Enhancing Resilience to Landslides Disasters through Rehabilitations of Slides Scars by local Communities in Mt. Elgon, Uganda

(Nakileza, Majaliwa, & Wandera, 2017) Examine the approaches and challenges faced by local populations in the rehabilitations of landslides degraded sites in specific area of Mt. Elgon, Uganda. The data collection was done through field surveys of purposive selected scars, key informants interview and focus group discussion with inhabitants. The stone terracing and afforestation measures were practiced by the population specifically in Bushika, it was proved that the scars can be recovered faster for efficient use. Such practices coupled with awareness and group works by community enhance their preparation levels to landslides disasters risks in the region. Restoring degraded landslides scars are essential, considering the high populations pressures in the region and the needs to attain enhanced environment sustainability and livelihoods. However, it is worthy to consider the various environmental and socio-economic challenges to reduce the landslides issues in such localities. Focus on affordable low cost technologies (e.g. afforestation and use of stone terraces) for small scale farmer in the rehabilitations of landslides scars is very favorable approaches.

2.7.2 Community-based Landslide Risk Reduction: A Review of a Red Cross Soil Bio-engineering for Resilience Program in Honduras

Persistent involvement of community people in DRR measure in landslides susceptible regions is a big challenge. This study evaluates the extent to which community based soil bio-engineering technique allows for efficient mitigations of shallow landslides given technical, environmental, economic and socio cultural sustainability criteria. The Red Cross has been implementing community based DRR program to increase resilience at the community level in Honduras since 2005. This case study validate that disaster risk reduction measures will be sustainable if we have systematic development of collaboration with community people. Soil bio-engineering techniques allow potential risks scenarios to become opportunity scenarios by using the spaces generated to create ecological orchards as an added value and community incentives. This contributes to sustainability by partially fulfilling beneficiaries' everyday needs. One of the objective is for households to seek about the efficient techniques executed in active site (bio-engineering and soils conservations technique), as well as agro-ecological measure so to copy those on their own lands and thus generates sustainable development processes at livelihoods levels. Such initiatives should therefore be highly encouraged to supports the implementation of the Sendai Framework. The fundamental element used to builds this relationships by the HRC/SRC (Honduran and Swiss Red Cross), includes the following: long term project duration (contact with the communities for five to 10 years); scientific risks studies combine with participative and inclusive mapping; analysis of vulnerabilities and capacity in each communities; formulation of communities disasters management committees; periodic visit to the communities; reliable delivery of promised services, which also require contributions from the communities; and development of community leaders' capacity building for project management. The high degree of credibility the Red Cross has established through long term community based project is a result of the reliability, flexibility and transparency of its approaches, which aim to create a high level of ownerships of the measure implemented, trusts and commitments from communities. This has led the Swiss Red Cross to strengthen their policy of promoting and implementing community based mitigations and bio-engineering in terms of (i) providing conceptual supports and capacity buildings through learning event and (ii) focusing more likely on community based mitigations and green measures in policy dialogue.

2.7.3 Using Multiple Vegetation Layers to Reduce the Risk of Rainfall-induced Landslide and facilitates post Landslides slopes Rehabilitations

This study proposes an interdisciplinary approach using multiple vegetation layers that combine a natural slope stability system and ecological theory for preventing and rehabilitating rainfall-induced, shallow landslides. Rainfall-induced landslides often result in huge financial costs and the loss of human lives. Rainfall-induced landslides are usually followed by heavy rain on slopes steeper than 30 degrees. Bare soils are recognized as unstable material contributing to slope failure. Landslides begin when a force is added to the unbalanced terrain. After heavy rain, the shallow portion of the landslide (depth: 1-2 m) is mainly caused by saturated soil and decreased of support of the slope toe. The deep portion of the landslide collapse (depth: 5-20 m) is mainly the result of water pressure increase in soil pores induced by groundwater increase following heavy rains and is referred to as a deep seated landslide. Vegetation cover has been used to enhance slope stability in the past decade. Healthy vegetation cover is essential to prevent rain induced landslide events. The roots systems can stable the soil to mitigate the risks of shallow landslide however the canopy can act as surcharge in strong wind and increase the risk of shallow landslides. This study suggests selecting proper plant species to strengthen the advantages of vegetation cover and minimize the disadvantage as indicated by Peduzzi. According to structure stability and vegetation ecology theory, if the root systems are more complicated and deeper, the soil is more stable and infiltration is higher. Therefore, well-develop roots system can helps to lessen runoff by shifting rainfalls water into ground water storages helps to minimize and stabilizes the slopes strains more efficiently. The same concept can also be applied to the plant canopy. When the plant canopy is more dense and complex, such as with trees and shrubs, the surface is shielded from wind and direct rainfall intercepted and redirected by the canopy. This suggests that grasses only or single species should be avoided for biotechnological slope stabilization. Balancing effectiveness with cost concerns, it is advised to use at least three different plant species to form three different layers in the vegetation canopy. This novel approach for rehabilitating rainfall-induced landslides is called multiple vegetation layers (Lu, 2014).

2.7.4 Rehabilitation of a Debris Flow Prone Mountain Stream in Southwestern China-Strategy, Effect and Implication

A rehabilitation program involving engineering measures such as check dams and dykes, biological measures such as reforestations and social measure like reduction in human disturbances has been started 30 years ago at a mountainous stream called Shengou creek that is susceptible to debris flow in south-western China. To stabilize the channels beds and hill slopes, small and medium sized check dams and dykes were built on important middle and upper areas of the creek. In the meantime, a drought resistant, highly adaptive and fast growing plant species Leucaena leucocephala, planted to recover vegetation and grasslands in the watersheds. The soils structures were improved and soils erosions were lowered on hill slopes after 7 years of development of trees, shrubs and herbs assemblage in the Leucaena leucocephala forests. Some families were shifted from upper areas to lower areas of the stream to minimize disturbances and cultivating practices on steep lands were strictly prohibited in the basins. These combined practices minimized sediments supplies from both hill slopes and upper parts of the stream, thus averting sediments related hazard (Yu, Huang, Wang, Brierley, & Zhang, 2012).

Chapter 3

RESEARCH METHODOLOGIES

3.1 RATIONALE OF THE CHAPTER

Appropriately to attain the aim and objective of the research works; this chapter particularly encompasses the methodology portion which was earlier mentioned in Chapter 1. The whole of the formulation of questionnaires as well as the design process in elaborated ahead. It also includes the details of the analysis of the data strategy is also portrayed.

3.2 DATA COLLECTION TOOLS

For the purpose of thorough analysis of the selected problem both primary and secondary data was collected from published journal articles, departmental reports, statistics of landslide hazard events and field data from the study area. A wide range of instruments have been used to collect data from target population. Two types of data i-e primary and secondary data were collected for achieving research objectives.

3.2.1 PRIMARY DATA

The primary data was collected from Jijal, Pattan, Dasu and Kamila area in time span of 3 months and 2 field visits. The data was collected through two data collection tools i-e Qualitative key informant interviews and Quantitative community questionnaire;

3.2.1.1 QUALITATIVE KEY INFORMANT INTERVIEWS

Detailed interviews of key departments working for hazard identification, timely provision of warning information and implementation of various mitigation measures, were conducted to evaluate their role in landslides and debris flow hazards mitigations. The representatives of the following key departments working at district level were interviewed for this purpose;

- ➢ District Disaster Management Unit (DDMU)/ DC office of district Kohistan Lower and Upper Kohistan
- ➢ Pakistan Red Crescent Society (PRCS), Kohistan Branch
- ➢ Forest Department

- Frontier Works Organization

3.2.1.2 QUANTITATIVE COMMUNITY QUESTIONNAIRE

For assessing any hazard it is important to gauge the perception of local communities about potential threat they are exposed to. Data collection was done through a questionnaire that was formulated through study of available studies on the research area, and field experts. Questionnaire was further divided into three sections; Part 1 with questions to asses existing knowledge of the community about landslide hazards in their area, Part 2 focuses on early warning mechanism and its information at community level and part 3 investigates disaster risk reduction measures being taken by district and tehsil level departments against landslide and debris flow hazard. The questionnaire is designed on Likert scale.

3.2.2 SECONDARY DATA

Secondary data is important in research process. Secondary data were collected by detailed literature review and from different standard journals, reports, articles, acts, online database, books, and relevant departments. The secondary data focused on the Disaster Risk Reduction Measures successfully practiced by different mountainous communities in several countries at govt. level and as well as community level.

3.3 STATISTICAL TOOLS FOR DATA ANALYSIS

For analysis of the collected data, a comprehensive software SPSS (Statistical Package for Social Sciences) and Microsoft office were used. Required operations added were applied on the data collected through Likert scale questionnaires. Graphs and bar charts were also built through frequency table and bar charts tools in SPSS. The interviews conducted from the officials of the targeted departments are manually presented which is the qualitative portion of the study, while some recommendations are also given on the basis of these key informant interviews.

3.4 RESEARCH DESIGN

According to (Saunders, Lewis, & Thornhill, 2003) a research strategy describes the layouts or designs depicting how the researcher has performed his study to attain the objectives and respond research question. It not only incorporates the sampling and questionnaire sampling but also the collection of data sources. Keeping in view the objective of the research; the research strategy is selected. There are three different research types mostly acceptable and utilized in the field of social sciences which includes; qualitative method, quantitative method and a combination of both qualitative and quantitative commonly known as "mixed mode approaches". The quantitative research method comprises of statistical data, Numerical data/analysis basing on the surveys and experimental work done and it uses deductive approach. While using the inductive approach, the qualitative method is the best approach as it draws the outcomes/results based on interviews or observations rather than using any statistical or numerical data (Amjad & A., 2004-2005). Since 1983-1996, Management journal research paper demonstrates that quantitative methods were dominated and used by 57 percent of the researchers. Only 8% used qualitative research methods and 13% utilized mixed methodology.

However, from period 1991-2001 Association of Researchers for Disaster Management revealed that qualitative and mixed mode approaches have got a boost in the upcoming times. (Seymour & Rooke, The Culture of the Industry and the Culture of Research, 1995) and (Seymour, Crooke , & Rooke, The Role of Theory in Construction Management: A Call for Debate, 1997) strongly support the use of qualitative approach. (Easterby, Thorpe, & Lowe, 1991) Believe that most research studies in management are based on mixed approach. The choice between quantitative or qualitative methods is highly dependent on the research aims/objective (Root, Fellows, & Hancock, 1997). Keeping in view the above statements, the basic aims of this research work is to identify the existing mitigation measures being taken in the study area with reference to landslide and debris flow hazards specifically along Karakoram Highway in district Kohistan.

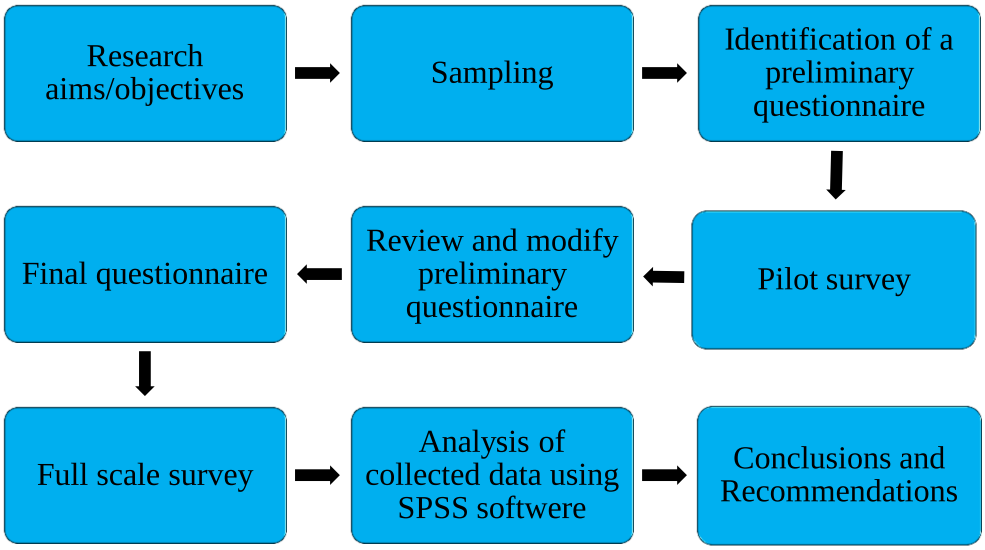

Figure 3.1 Research Methodology

For this purpose, data is required from different categories of the community; dividing them in different classes keeping in mind their age, status and experiences.

Figure 3.1 highlights the steps being followed for this research study. In this process, two different surveys were conducted. Firstly, a pilot survey was arranged to validate, refine and improve the questionnaire. Then a full scale survey was carried out to collect the requisite data. At the end, analysis of the collected data has been done to find out the actual outcome/results.

3.5 THE SURVEY DESIGN PROCESS

According to (Marsh, 1982), survey is defines as "data collected from number of cases/projects through systematic measurement and then analyzed to yield the results. (Trochim & M., 1997) And (Bryman, 2004) argued that in applied social research, surveys are mostly carried out by questionnaire and interview surveys. (Bryman, 2004) Referred surveys as cross-sectional studies and explained that the data collected from the surveys are generally quantitative in nature and can be used to correlate two or more variables. (Trochim & M., 1997) Suggest that population, sampling and question issues are the parameters which should be kept in mind when a survey is selected as a research strategy. The survey design chosen for this research is shown in the Figure 3.2 (Shuwei, 2009).

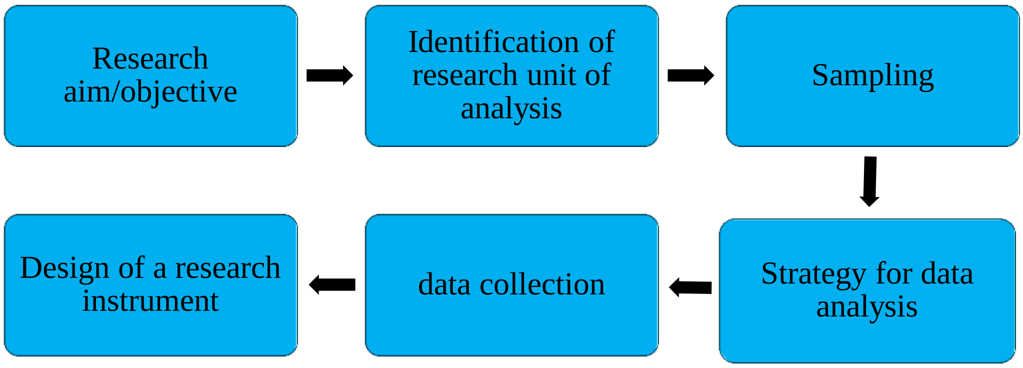

Figure 3.2 Research Design

3.6 SAMPLING

Sampling explains the “numbers of respondent”. These numbers of respondent are chosen from the total populations of the area selected for the survey process. For the purpose of this study, 200 questionnaires were filled from the public residing near to the landslide and debris flow risk sites along Karakoram Highway in Kohistan district. The researcher filled questionnaires from those people who had basic knowledge about landslides and debris flow hazard and disaster management. Likert scale was given in the questionnaire in which the respondent’s satisfaction level against the relevant departments was checked.

By using the following formula presented by Dillman (2000), the sample size was calculated for this research;

$$Ns = \frac{\mathrm{Np} * \mathrm{P} * (1 - \mathrm{P})}{[(\mathrm{Np} - 1) * (\mathrm{B}/\mathrm{C})^2] + [\mathrm{P} * (1 - \mathrm{P})]}$$

Where;

- Ns: Sample size
- Np: Population size
- P: Expected Response Proportion; P = 0.5
- B: Margin of Error; (10% or 0.10)
- C: Z statistic associated with the Confidence level (1.645 corresponds to 90% Confidence level)

The resulted sample size calculated through the applied formula was 200 numbers of respondents.

3.7 PILOT SURVEY

A pilot survey was arranged to validate, refine and improve the primary questionnaires in order to bring modifications and improvements before a full scale survey could be conducted.

3.7.1 Expert Opinion

Experts from academia with specialization in disaster management were contacted to revise and improve the questionnaire accordingly.

3.7 2 Departmental Interviews

For studying the social aspects of a community, the most accepted and common methodology used is qualitative interviews. These interviews are often "conversational" at the same time as being formed to collect the required information from the studied group of informants. Some questions and topics will be pre-arranged, whereas many questions will emerge during the interviewing process (Kish, 1995).

Interviews comprise in depth analysis of four key departments. Other than questionnaire, senior official of departments concerning disaster management were contacted. Officials from District Disaster Management Unit, Pakistan Red Crescent Society, Forest Department and Frontier Works Organization were interviewed.

3.8 QESTIONNAIRE FINALIZATION

After refining the primary questionnaires, separate questionnaire was formulated for community and the four departments concerned with disaster management. A five numeric scale followed was 1-Very Low, 2-Low, 3-Average, 4-High and 5-Very High, for both community and departmental survey to access respondent's attitude towards each parameter. The questionnaires were formulated in accordance with local environmental and social contexts. Questionnaires were kept simple and precise for easy understanding of the respondents and to get maximum output from the survey.

The questionnaire includes introduction of the respondents, gender, age and profession. Community questionnaires were formulated for local inhabitants of the community. Separate questionnaires were developed for each department in view of their relevance and role in disaster management. Questionnaires comprised of 40 questions covering all the parameters which were then statistically analyzed using a 5 point Likert scale to determine relevant importance of each factor.

3.9 FULL SCALE SURVEY

A full scale survey was carried out in both the departmental as well as general community case for this particular study. Delivering the questionnaire by oneself is appropriate enough for a couple of reasons argued by (Bell, 2005) which elaborated that this kind of approach brings with itself better understanding of the purpose of research; it overcomes all the difficulties faced by the respondents while filling up the questionnaire; face to face communication is done in the completion of this process so that there is no room left for any doubt; high response rate is achieved and questionnaires are sorted out easily as well as it saves time by obtaining the responses on the spot rather than waiting for it and setting a certain time frame. The targeted area in this case was Kohistan district specifically the locality living close to Karakoram Highway. It was accessible to the researcher so most of the questionnaire was delivered to the respondents personally. 200 numbers of questionnaires were filled from the respondents in the community.

Chapter 4

RESULTS AND DISCUSSIONS

4.1 RATIONALE OF THE CHAPTER

This chapter elaborates the practical statistical analysis of collected data and presents the results. These results have been obtained by using the most comprehensible software i.e. SPSS. These research proceedings are all about the Community Resilience to Landslide and Debris Flow Hazards in Kohistan District. Therefore, different departments' official was interviewed and their responses were recorded through a Likert scale questionnaires to find out their responses. Apart from this the general community residing close to main Karakoram Highway was also under consideration and a full scale questionnaire based survey was conducted there as well. A total of four different questionnaires were developed for each concerned departments. On the other hand the community questionnaire was classified in three portions i.e. General Information regarding Landslide and Debris Flow Hazard in their area, Early Warning Information, and Disaster Risk Reduction Measures.

4.2 DEMOGRAPHIC INFORMATIONS OF THE RESPONDENT

4.2.1 Gender of the Respondent

Gender analysis of the respondent show that 93.5 % of the respondents were male and 6.5 % were female. Due to very low literacy ratio and cultural barriers, female respondents were not consulted. The 6.5 % female respondents consulted were female health technicians, LHVs and female school teachers working in the locality since many years but were from other districts. Every possible mean was used to increase the number of female respondents but due to cultural barrier only 6.5 % were consulted.

Table 4.1 Gender of the Respondent

Gender	Frequency	Percent	Valid Percent	Cumulative Percent
Male	187	93.5	93.5	93.5
Female	13	6.5	6.5	100.0
Total	**200**	**100.0**	**100.0**	

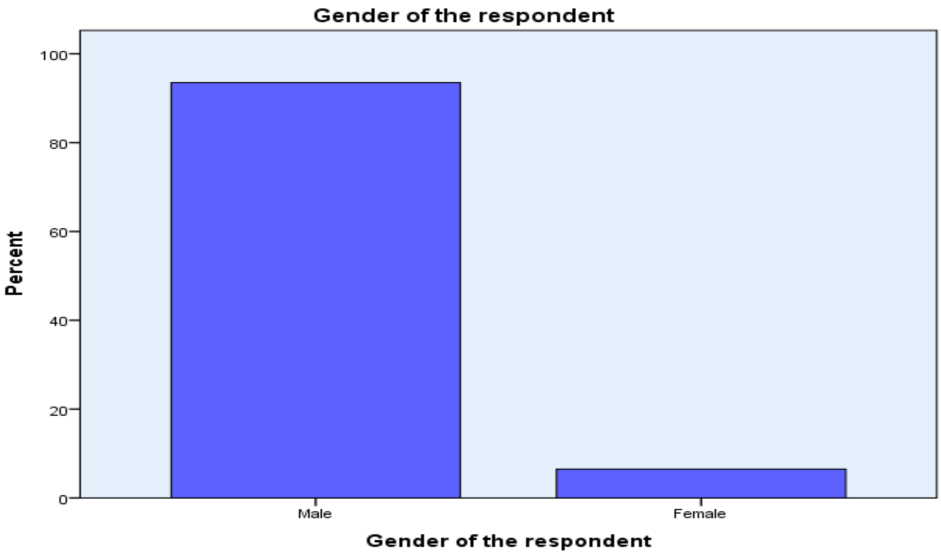

Figure 4.1 Gender of the Respondent

4.2.2 Age of the Respondent

Age wise distribution of the respondent is shown in Table 4. 2 and same is shown in Figure 4. 2 as well. Respondents from all the age group participated in the survey. More than 60 % of the respondents were between age groups 26-45.

Table 4. 2 Age of the Respondents

Age groups	Frequency	Percent	Valid Percent	Cumulative Percent
16-25	31	15.5	15.5	15.5
26-35	68	34.0	34.0	49.5
36-45	55	27.5	27.5	77.0
46-55	29	14.5	14.5	91.5
56-65	17	8.5	8.5	100.0
Total	**200**	**100.0**	**100.0**	

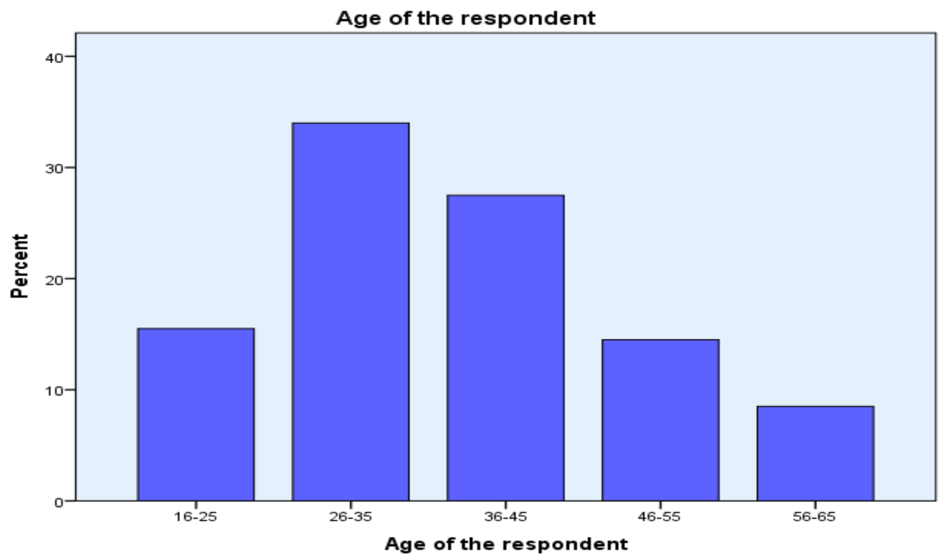

Figure 4. 2 Age of the Respondent

4.2.3 Education Background of the Respondents

The tabular and graphical distributions of respondents' education background are displayed in Table 4. 3 and Figure 4. 3 respectively. Education analysis of the respondent shows that 7.5 percent of the respondents were illiterate, 9.0 percent were matriculate, 28.0 percent were intermediate passed, 33.5 percent were bachelor and 22.0 percent were graduates in various fields.

Table 4. 3 Education of the Respondent

Educational level	Frequency	Percent	Valid Percent	Cumulative Percent
Illiterate	15	7.5	7.5	7.5
Matriculate	18	9.0	9.0	16.5
Intermediate	56	28.0	28.0	44.5
Bachelor	67	33.5	33.5	78.0
Graduate	44	22.0	22.0	100.0
Total	**200**	**100.0**	**100.0**	

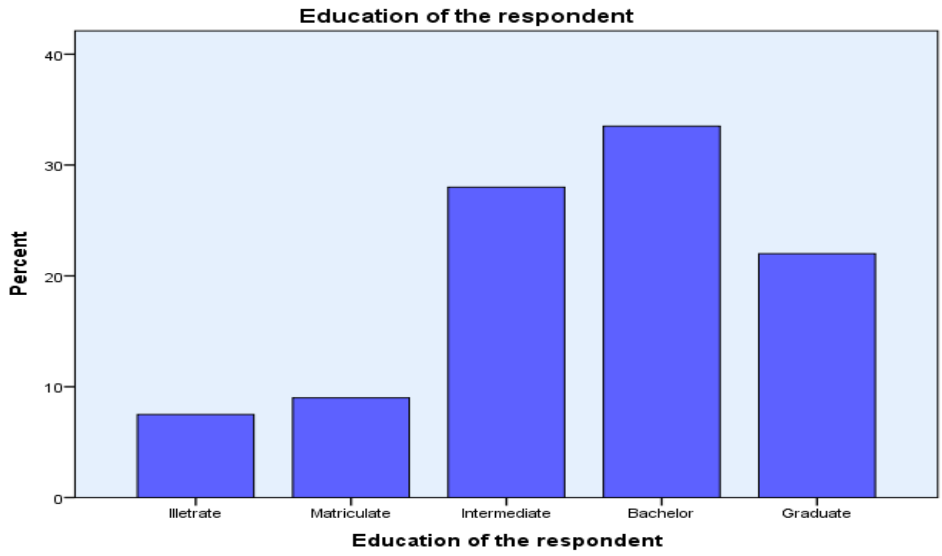

Figure 4. 3 Education of the Respondent

4.3 COMMUNITY KNOWLEDGE REGARDING LANDSLIDES AND DEBRIS FLOWS DISASTERS IN THE AREA

4.3.1 Prior Knowledge about Landslide and Debris Flow Hazards

Basing on the data collected, almost 80 % of the respondents have average, high and very high prior knowledge about landslide/debris flow hazard respectively which is a sign of frequent disaster events on main Karakoram Highway .It clearly portrays the level of ignorance in the public.

Table 4. 4 Prior Knowledge

Response	Frequency	Percent	Valid Percent	Cumulative Percent
Very Low	9	4.5	4.5	4.5
Low	33	16.5	16.5	21.0
Average	67	33.5	33.5	54.5
High	65	32.5	32.5	87.0
Very High	26	13.0	13.0	100.0
Total	**200**	**100.0**	**100.0**	

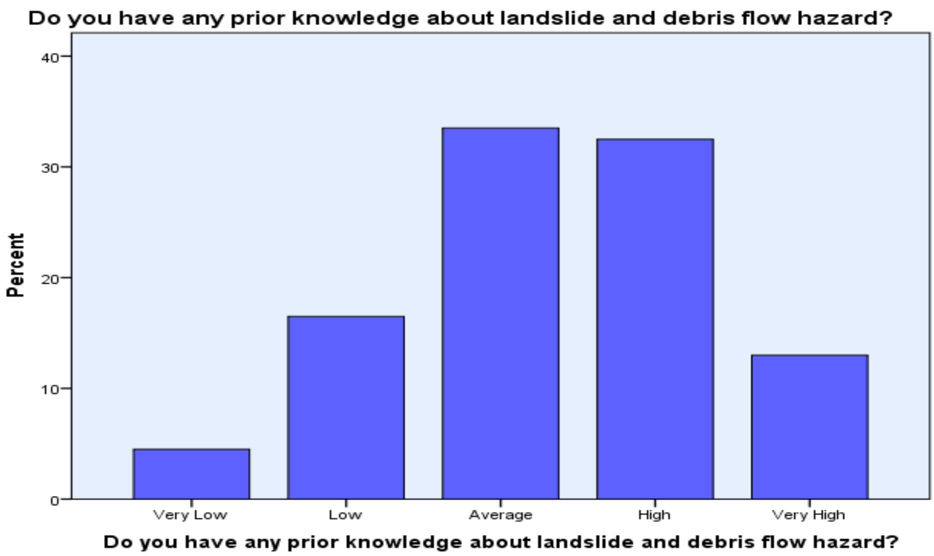

Figure 4. 4 Prior Knowledge

4.3.2 Experience of Past Landslides and Debris Flows Disasters

The rate of experience of past landslides and debris flows disasters are high which shows that frequent disasters occurred in the past as mentioned in Table 4.5 and Figure 4.5.

Table 4. 5 Experience of disaster

Response	Frequency	Percent	Valid Percent	Cumulative Percent
Very Low	9	4.5	4.5	4.5
Low	31	15.5	15.5	20.0
Average	67	33.5	33.5	53.5
High	63	31.5	31.5	85.0
Very High	30	15.0	15.0	100.0
Total	**200**	**100.0**	**100.0**	

Figure 4. 5 Experience of disaster

4.3.3 Common Damages as a result of Landslide and Debris Flow Disaster

Damages analysis shows that 5.0 % of the respondents responded very low, 14.5 % responded low, 30.5 % responses were average, 30.5 % responses were high for the damages caused by Landslides and debris flows disasters and 19.5 % responses were very high.

Table 4. 6 Damages of disasters

Response	Frequency	Percent	Valid Percent	Cumulative Percent
Very Low	10	5.0	5.0	5.0
Low	29	14.5	14.5	19.5
Average	61	30.5	30.5	50.0
High	61	30.5	30.5	80.5
Very High	39	19.5	19.5	100.0
Total	**200**	**100.0**	**100.0**	

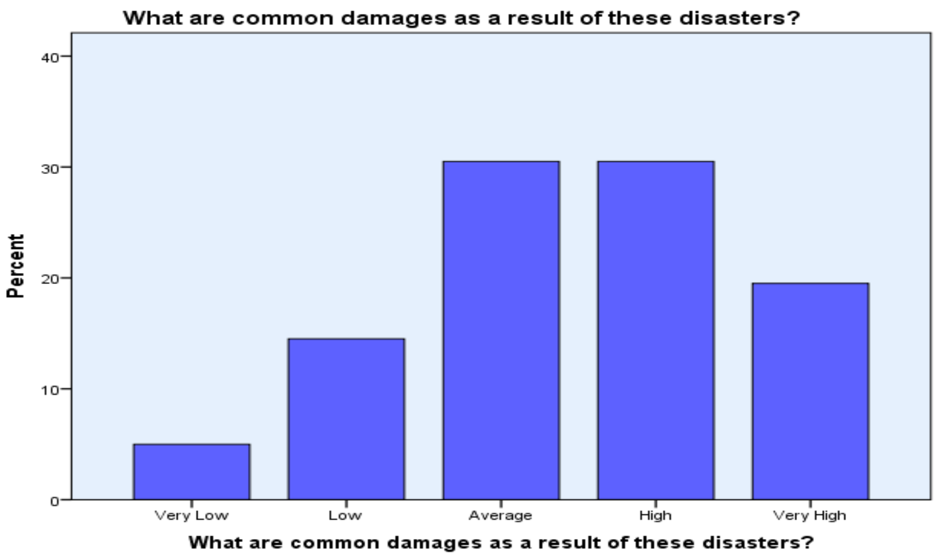

Figure 4. 6 Damages of disaster

4.3.4 First Response in case of a Landslide/Debris Flow Event

10.0 % respondents responded very low, 29.0 % responses were low, 26.5 % responses were average for the first response of the general public in case of a landslides/debris flows events, 22.5 % responded high and 12.0 % responses were very high.

Table 4. 7 Community First Response

Response	Frequency	Percent	Valid Percent	Cumulative Percent
Very Low	20	10.0	10.0	10.0
Low	58	29.0	29.0	39.0
Average	53	26.5	26.5	65.5
High	45	22.5	22.5	88.0
Very High	24	12.0	12.0	100.0
Total	**200**	**100.0**	**100.0**	

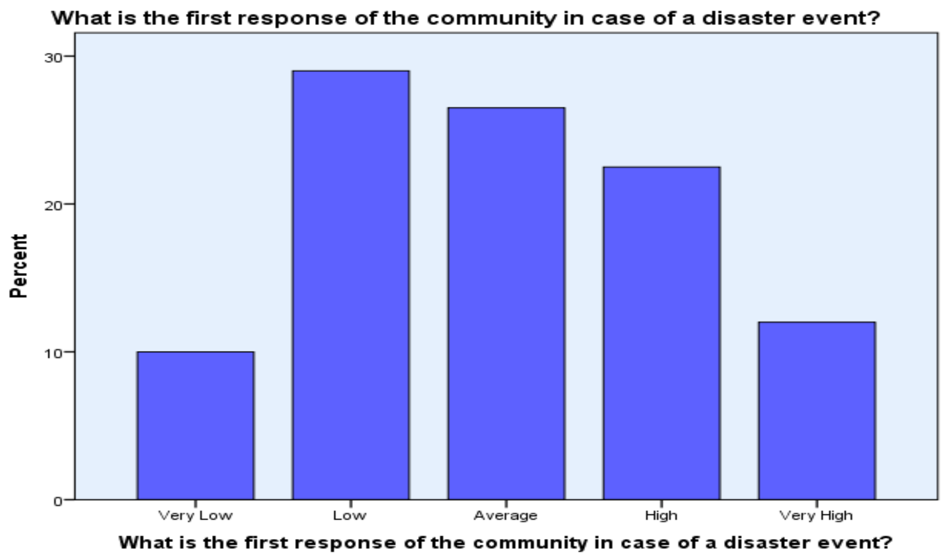

Figure 4. 7 Community First Response

4.3.5 District Disaster Management Authority Functioning

As per collected data more than 57 % of the responses were in negative about the functioning of DDMA, 17.0 % responses were average and 2.5 % responses were high and very high respectively.

Table 4. 8 DDMA Functional/ Working

Response	Frequency	Percent	Valid Percent	Cumulative Percent
Very Low	81	40.5	40.5	40.5
Low	75	37.5	37.5	78.0
Average	34	17.0	17.0	95.0
High	5	2.5	2.5	97.5
Very High	5	2.5	2.5	100.0
Total	**200**	**100.0**	**100.0**	

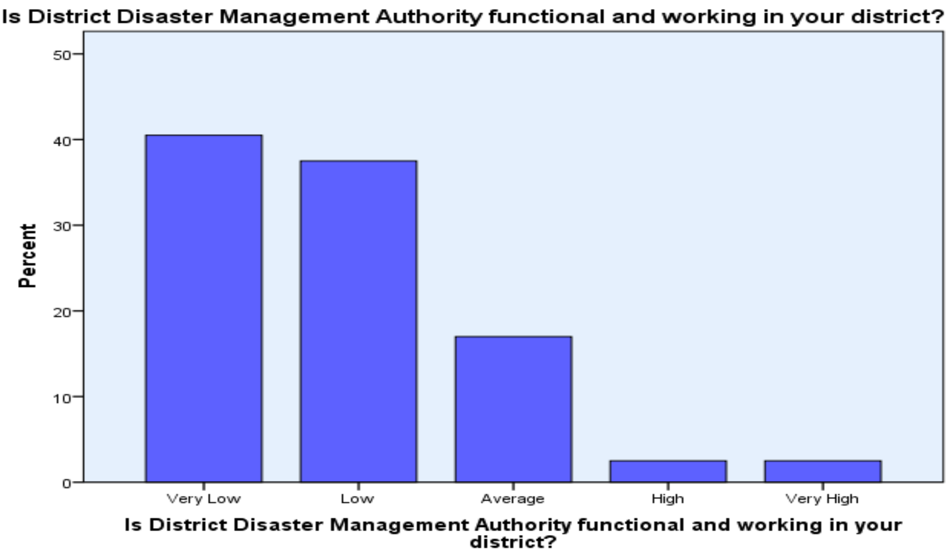

Figure 4. 8 DDMA Functional/ Working

4.3.6 Local Authorities Support in Times of Disaster

On inquiring about the local authorities support regarding landslide/debris flow disaster 75 percent of the respondents responded negatively which is an alarming situation for the public. 18.0 % responses were of average, 4.5 % responses were of high and only 2.0 % responses were very high in this regard.

Table 4. 9 Support from Local Authority

Response	Frequency	Percent	Valid Percent	Cumulative Percent
Very Low	81	40.5	40.5	40.5
Low	70	35.0	35.0	75.5
Average	36	18.0	18.0	93.5
High	9	4.5	4.5	98.0
Very High	4	2.0	2.0	100.0
Total	**200**	**100.0**	**100.0**	

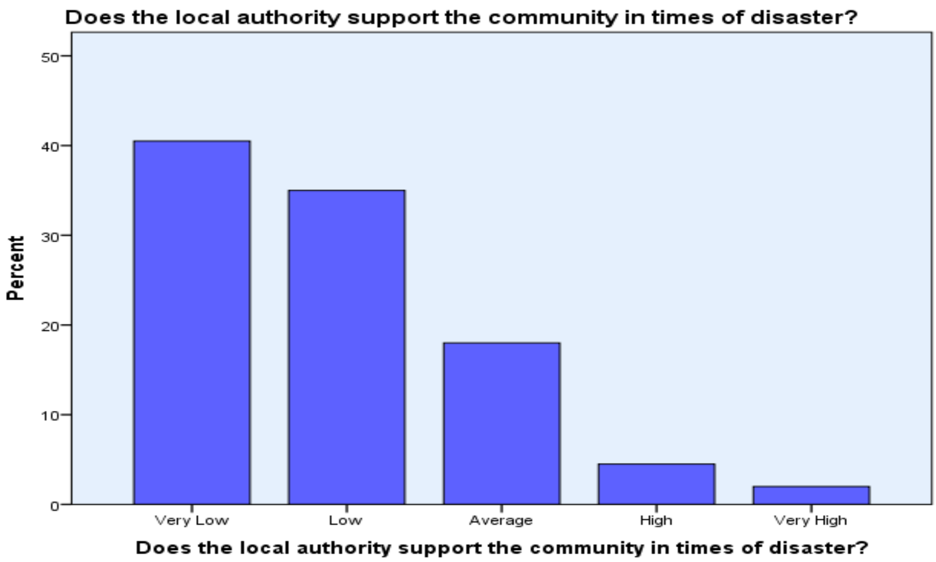

Figure 4. 9 Support from Local Authority

4.3.7 Positive Change after DDMA Development

39.0 % of the respondents responded in very low, 14 % of the responses were low in this aspect. This shows very less positive change after the development of DDMA.

Table 4. 10 Positive Change after DDMA Development

Response	Frequency	Percent	Valid Percent	Cumulative Percent
Very Low	85	42.5	42.5	42.5
Low	78	39.0	39.0	81.5
Average	28	14.0	14.0	95.5
High	5	2.5	2.5	98.0
Very High	4	2.0	2.0	100.0
Total	**200**	**100.0**	**100.0**	

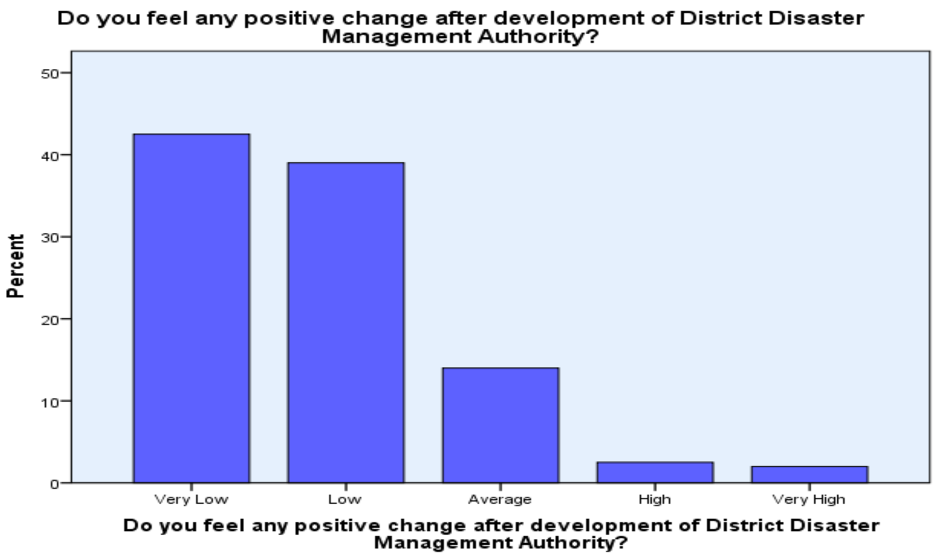

Figure 4. 10 Positive Change after DDMA Development

4.4 EARLY WARNING INFORMATION

4.4.1 Provision of Warning/Information regarding Landslide/Debris Flow Disaster

On asking about the provision of warning/information regarding landslide and debris flow disaster, almost ninety percent responded negatively. There is no mechanism adopted to date for the provision of information about landslide/debris flow to the community.

Table 4. 11 Provision of Warning Information

Response	Frequency	Percent	Valid Percent	Cumulative Percent
Very Low	101	50.5	50.5	50.5
Low	78	39.0	39.0	89.5
Average	19	9.5	9.5	99.0
Very High	2	1.0	1.0	100.0
Total	**200**	**100.0**	**100.0**	

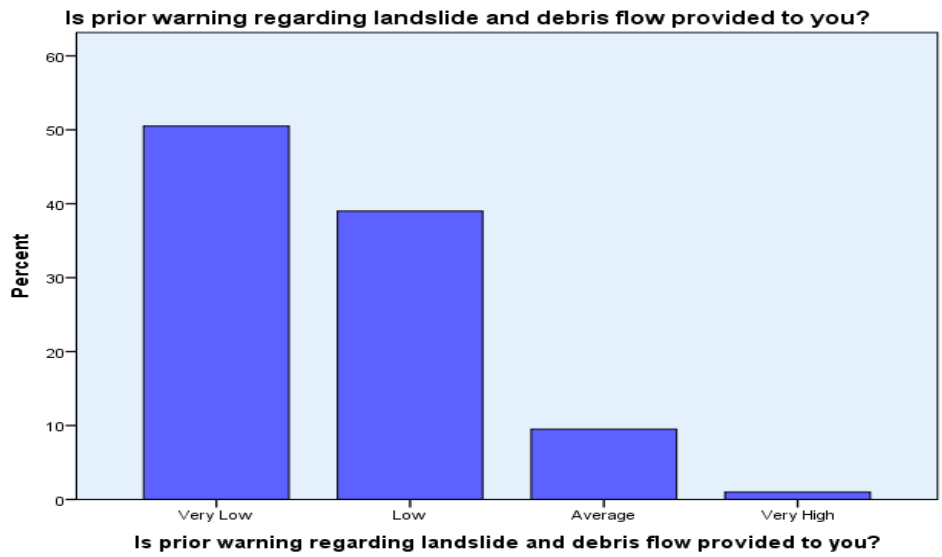

Figure 4. 11 Provision of Warning Information

4.4.2 Early Warning System Known from forefather's Time

Only 14 % respondents responded positive for the early warning system known from their forefather's time.

Table 4. 12 Early Warning System Known from forefather's Time

Response	Frequency	Percent	Valid Percent	Cumulative Percent
Very Low	93	46.5	46.5	46.5
Low	79	39.5	39.5	86.0
Average	23	11.5	11.5	97.5
High	4	2.0	2.0	99.5
Very High	1	.5	.5	100.0
Total	**200**	**100.0**	**100.0**	

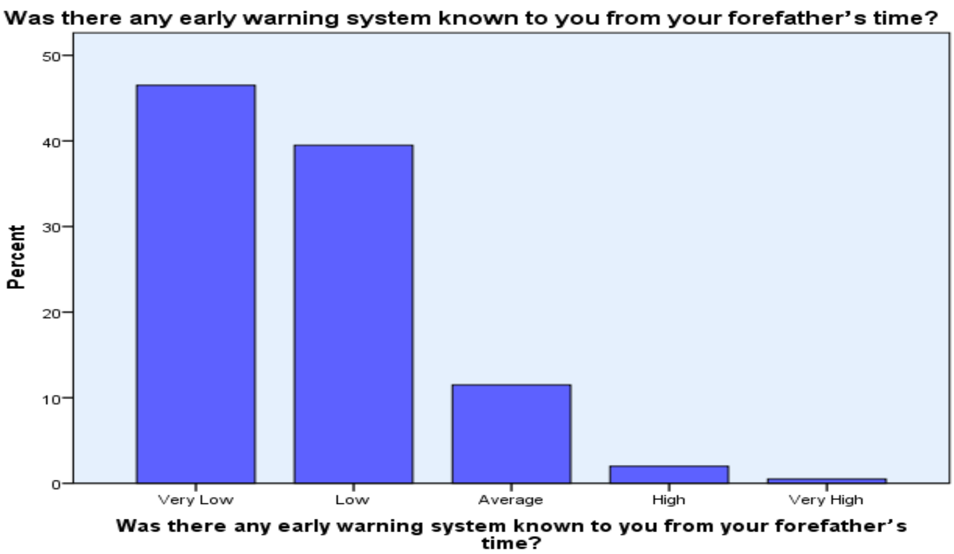

Figure 4. 12 Early Warning System Known from forefather's Time

4.4.3 Early Warning System Working

On asking about the working of EWS known from their forefather's time, only 11.0 % of the respondents answered positively as per the collected data.

Table 4. 13 Early Warning System Working

Response	Frequency	Percent	Valid Percent	Cumulative Percent
Very Low	104	52.0	52.0	52.0
Low	74	37.0	37.0	89.0
Average	18	9.0	9.0	98.0
High	3	1.5	1.5	99.5
Very High	1	.5	.5	100.0
Total	**200**	**100.0**	**100.0**	

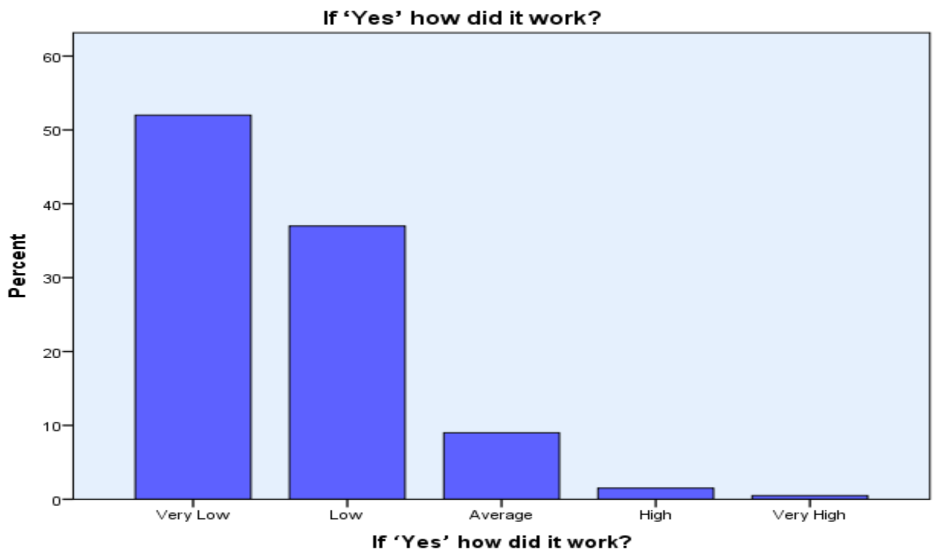

Figure 4. 13 Early Warning System Working

4.4.4 Information Dissemination within the Community

Only 25 % of the responses answered in positive about information dissemination within the community. It means information dissemination mechanism is too weak in the study area.

Table 4. 14 Information Dissemination

Response	Frequency	Percent	Valid Percent	Cumulative Percent
Very Low	50	25.0	25.0	25.0
Low	105	52.5	52.5	77.5
Average	38	19.0	19.0	96.5
High	6	3.0	3.0	99.5
Very High	1	.5	.5	100.0
Total	**200**	**100.0**	**100.0**	

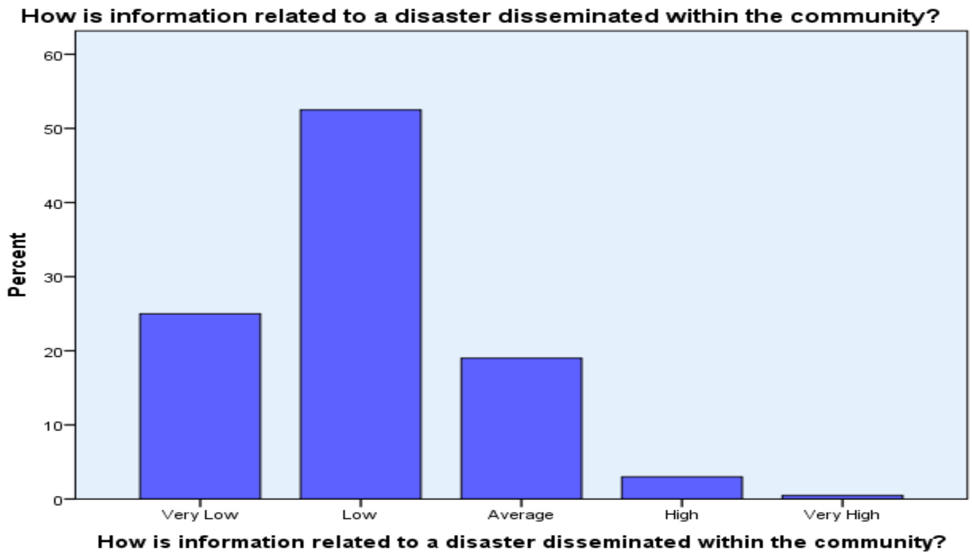

Figure 4. 14 Information Dissemination

4.4.5 Landslides Monitoring and Warnings Systems

The landslide monitoring and warnings systems were very weak as per collected data from the respondents. Only 3 % respondent's responses were in positive as per the set parameters.

Table 4. 15 Landslide Monitoring and Warning System

Response	Frequency	Percent	Valid Percent	Cumulative Percent
Very Low	59	29.5	29.5	29.5
Low	86	43.0	43.0	72.5
Average	49	24.5	24.5	97.0
High	3	1.5	1.5	98.5
Very High	3	1.5	1.5	100.0
Total	**200**	**100.0**	**100.0**	

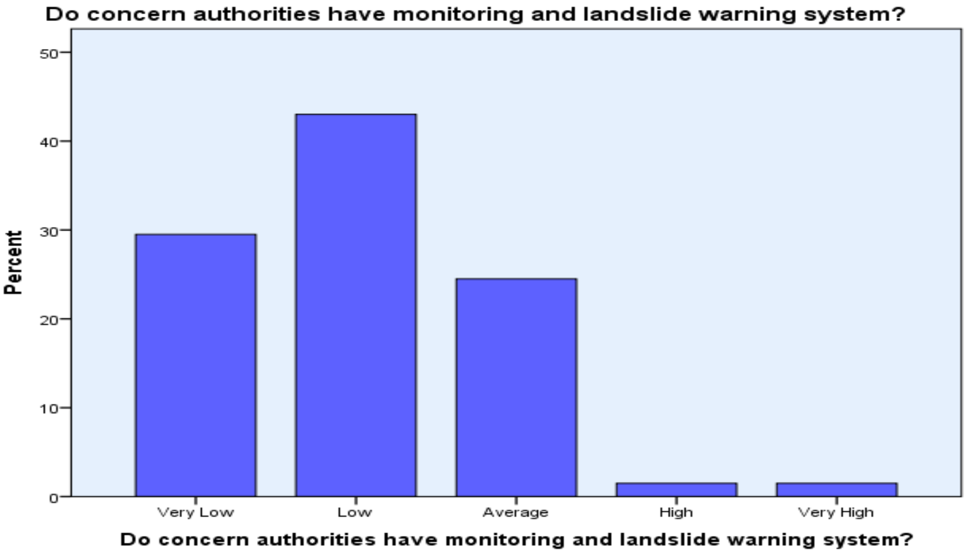

Figure 4. 15 Landslide Monitoring and Warning System

4.4.6 Trust of Community in the Warnings Issued

Nearly 50 % responses were in negative as per the survey for the trust community has in the warnings issued to them.

Table 4. 16 Trust of Community

Response	Frequency	Percent	Valid Percent	Cumulative Percent
Very Low	40	20.0	20.0	20.0
Low	55	27.5	27.5	47.5
Average	84	42.0	42.0	89.5
High	19	9.5	9.5	99.0
Very High	2	1.0	1.0	100.0
Total	**200**	**100.0**	**100.0**	

Figure 4. 16 Trust of Community

4.4.7 Beliefs in the Warnings

17.5 % responses were very low, 27.0 % responses were low, and 38.0 % responses were average against belief in the warnings by local authorities. 14.0 respondents responded high and 3.5 % were very high.

Table 4. 17 Beliefs in the Warnings

Response	Frequency	Percent	Valid Percent	Cumulative Percent
Very Low	35	17.5	17.5	17.5
Low	54	27.0	27.0	44.5
Average	76	38.0	38.0	82.5
High	28	14.0	14.0	96.5
Very High	7	3.5	3.5	100.0
Total	**200**	**100.0**	**100.0**	

Figure 4. 17 Belief in the Warnings

4.4.8 Information Credibility, Reliability and Authenticity

More than 60 % of the responses were against the credibility, reliability and authenticity of the disseminated information as per the survey.

Table 4. 18 Information Credibility, Reliability and Authenticity

Response	Frequency	Percent	Valid Percent	Cumulative Percent
Very Low	45	22.5	22.5	22.5
Low	84	42.0	42.0	64.5
Average	51	25.5	25.5	90.0
High	17	8.5	8.5	98.5
Very High	3	1.5	1.5	100.0
Total	**200**	**100.0**	**100.0**	

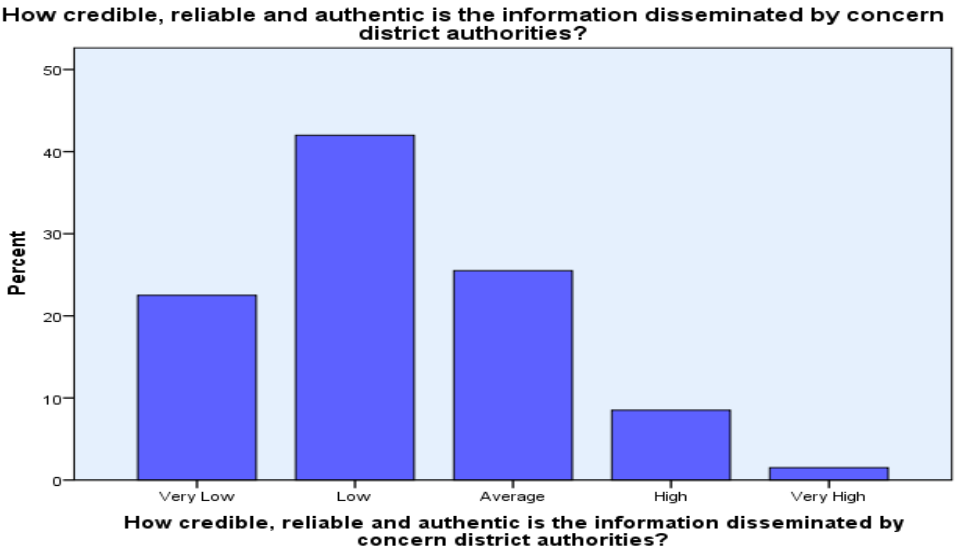

Figure 4. 18 Information Credibility, Reliability and Authenticity

4.4.9 Community Preparation after Early Warning Information Dissemination

71 % of the respondents had no preparation for landslide/debris flow after early warning information dissemination as by the Table 4.3.9 and Figure 4.3.9 respectively.

Table 4. 19 Community Preparation

Response	Frequency	Percent	Valid Percent	Cumulative Percent
Very Low	61	30.5	30.5	30.5
Low	81	40.5	40.5	71.0
Average	37	18.5	18.5	89.5
High	14	7.0	7.0	96.5
Very High	7	3.5	3.5	100.0
Total	**200**	**100.0**	**100.0**	

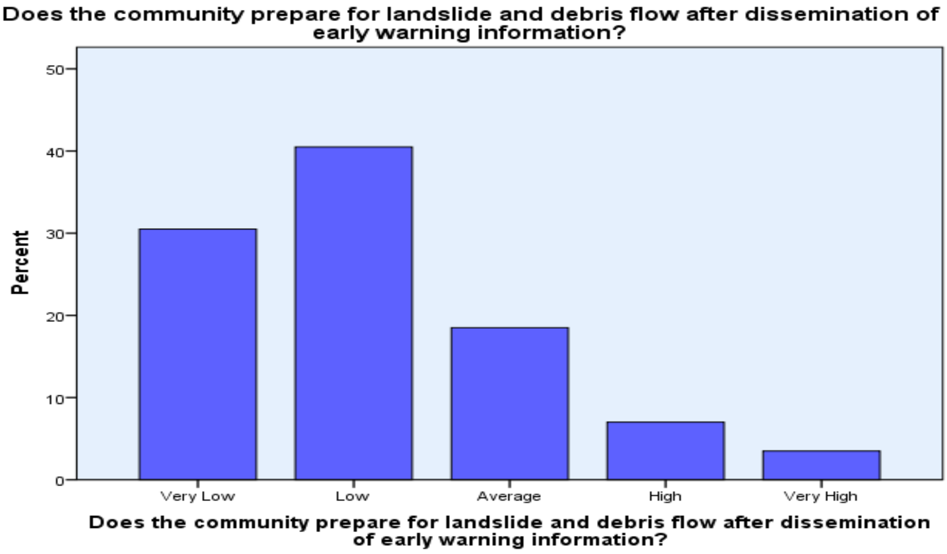

Figure 4. 19 Community Preparation

4.5 DISASTER RISK REDUCTION MEASURES

4.5.1 DRR Measures

It is necessary for the concerned authorities to develop risk reduction measures for the reduction and mitigation of disaster to enhance community resilience to cope with. As per the survey conducted, more than 80 percent of the responses were in negative.

Table 4. 20 DRR Measures

Response	Frequency	Percent	Valid Percent	Cumulative Percent
Very Low	86	43.0	43.0	43.0
Low	78	39.0	39.0	82.0
Average	21	10.5	10.5	92.5
High	10	5.0	5.0	97.5
Very High	5	2.5	2.5	100.0
Total	**200**	**100.0**	**100.0**	

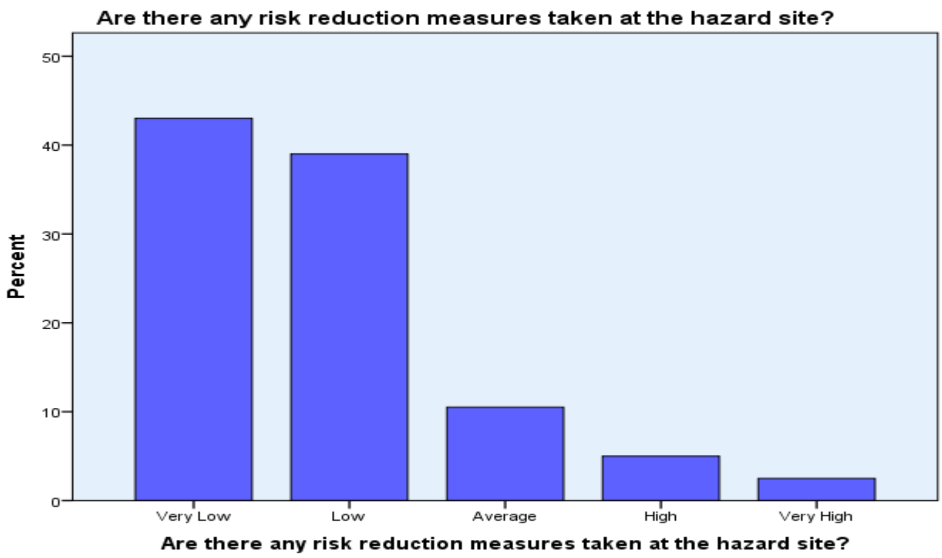

Figure 4. 20 DRR Measures

4.5.2 Community Educated and Trained while dealing with Disasters

Community Education and training for the preparation against the upcoming disasters include the siren for early warning, issuance of warning through masjid, community center, TV cable networks, local newspaper and other available means of communications. 85 percent of the respondents answered in negative as per the survey conducted, which depicts the sign of ignorance.

Table 4. 21 Community Educated and Trained

Response	Frequency	Percent	Valid Percent	Cumulative Percent
Very Low	96	48.0	48.0	48.0
Low	77	38.5	38.5	86.5
Average	16	8.0	8.0	94.5
High	8	4.0	4.0	98.5
Very High	3	1.5	1.5	100.0
Total	**200**	**100.0**	**100.0**	

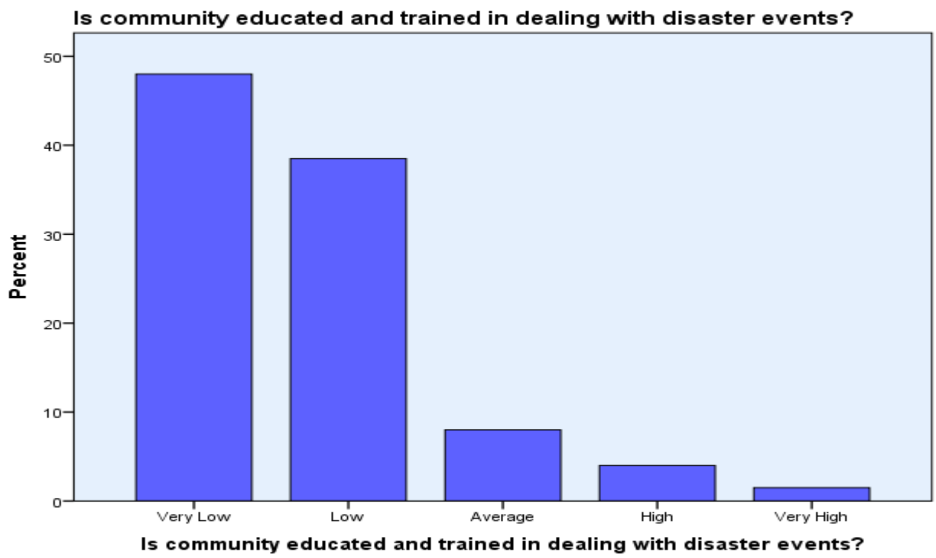

Figure 4. 21 Community Educated and Trained

4.5.3 Planned Relocation of Community to Safe Places

The results of the conducted survey depicts that 85 percent respondents denied for any planned relocation of communities to safer places in times of disaster.

Table 4. 22 Planned Relocation of Community

Response	Frequency	Percent	Valid Percent	Cumulative Percent
Very Low	93	46.5	46.5	46.5
Low	77	38.5	38.5	85.0
Average	25	12.5	12.5	97.5
High	4	2.0	2.0	99.5
Very High	1	.5	.5	100.0
Total	**200**	**100.0**	**100.0**	

Figure 4. 22 Planned Relocation of Community

4.5.4 Deforestation Surveillance System

As per the survey, only 20 % of the respondents reported that there is deforestation surveillance system in their area.

Table 4.23 Deforestation Surveillance system

Response	Frequency	Percent	Valid Percent	Cumulative Percent
Very Low	53	26.5	26.5	26.5
Low	52	26.0	26.0	52.5
Average	56	28.0	28.0	80.5
High	30	15.0	15.0	95.5
Very High	9	4.5	4.5	100.0
Total	**200**	**100.0**	**100.0**	

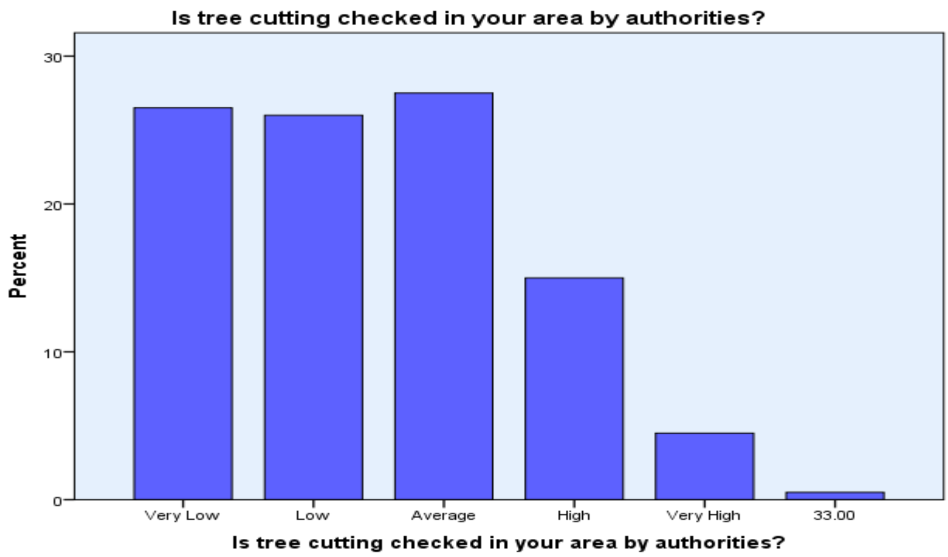

Figure 4. 23 Deforestation Surveillance Systems

4.5.5 Afforestation under Khyber Pakhtukhwa Billion Tree Afforestation Project

Khyber Pakhtunkhwa Government under its tenure from 2013-2018 launched a Billion Tree Afforestation Project in KPK which sustain very successful in combating climate change and provide a support for other social measures to be implemented on a wide range. The survey conducted to identify whether BTAP implementations were in consideration with mitigation of landslides and debris flows disasters in Kohistan district. The report depicts approximately 40 percent of the responses in favour of BTAP implementations in consideration with the mitigation of landslides and debris flow disasters in the study area.

Table 4. 24 Afforestation under Khyber Pakhtukhwa Billion Tree Afforestation Project

Response	Frequency	Percent	Valid Percent	Cumulative Percent
Very Low	25	12.5	12.5	12.5
Low	28	14.0	14.0	26.5
Average	69	34.5	34.5	61.0
High	63	31.5	31.5	92.5
Very High	15	7.5	7.5	100.0
Total	**200**	**100.0**	**100.0**	

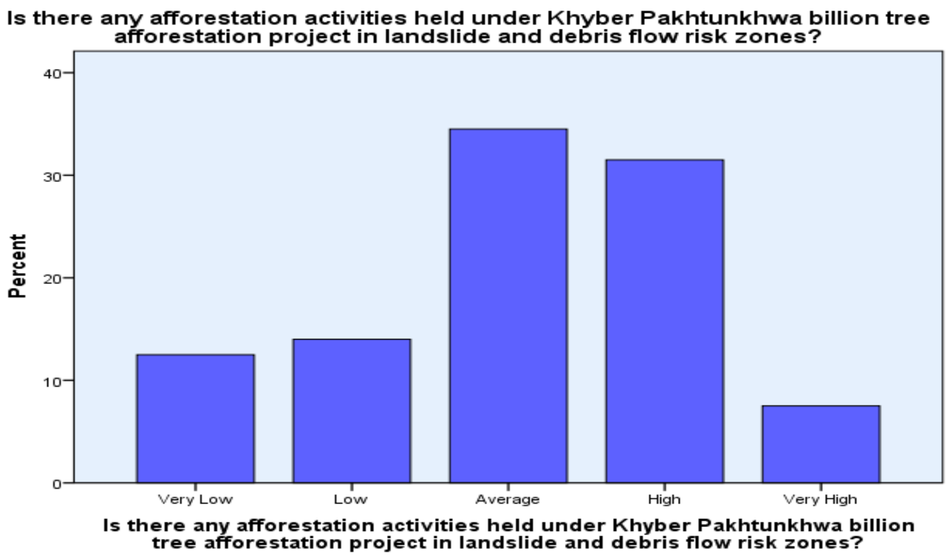

Figure 4. 24 Afforestation under Khyber Pakhtukhwa Billion Tree Afforestation Project

4.5.6 Culverts and Water Channels

On asking about building of culverts and water channels on main Karakoram highway for adequate channelization of rain water disposal, only 10.5 percent respondents were in favour as per the study.

Table 4. 25 Culverts and Water Channels

Response	Frequency	Percent	Valid Percent	Cumulative Percent
Very Low	42	21.0	21.0	21.0
Low	54	27.0	27.0	48.0
Average	83	41.5	41.5	89.5
High	20	10.0	10.0	99.5
Very High	1	.5	.5	100.0
Total	**200**	**100.0**	**100.0**	

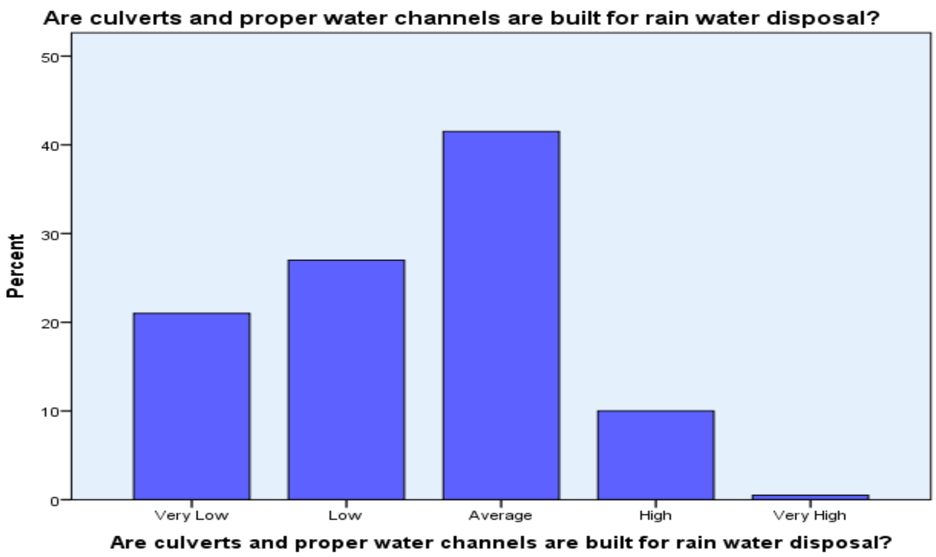

Figure 4. 25 Culverts and Water Channels

4.5.7 Retaining Wall and Discharge Tunnel

As per the survey conducted, 58 percent respondents responded very low and low respectively.

Table 4. 26 Retaining Wall and Discharge Tunnel

Response	Frequency	Percent	Valid Percent	Cumulative Percent
Very Low	45	22.5	22.5	22.5
Low	71	35.5	35.5	58.0
Average	63	31.5	31.5	89.5
High	20	10.0	10.0	99.5
Very High	1	.5	.5	100.0
Total	**200**	**100.0**	**100.0**	

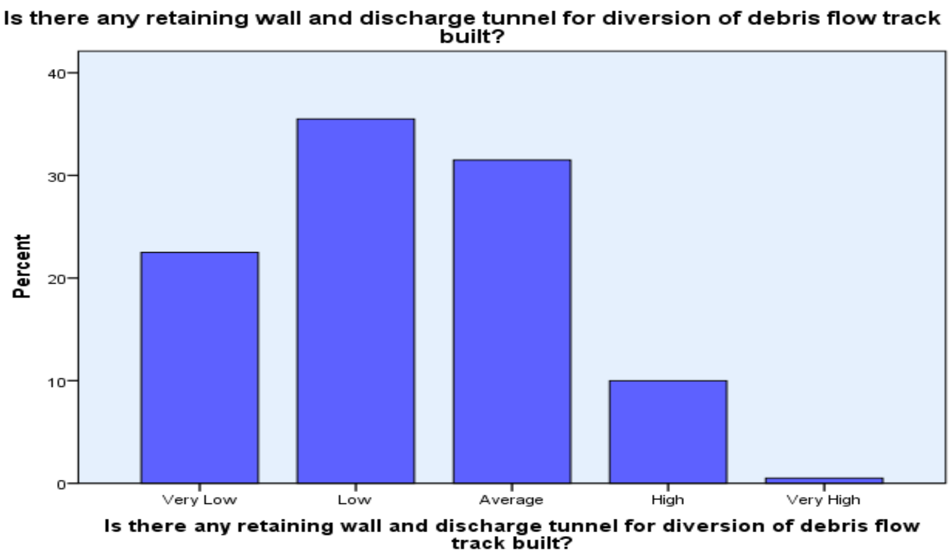

Figure 4. 26 Retaining Wall and Discharge Tunnel

4.5.8 Soil and Water Conservation

Forest and grassland protection is essential for conservation of soil and water. 75 percent responses were against the question asked. Lack of proper forest and grassland conservation mechanisms lead to high frequency of erosion processes.

Table 4. 27 Soil and Water Conservation

Response	Frequency	Percent	Valid Percent	Cumulative Percent
Very Low	51	25.5	25.5	25.5
Low	99	49.5	49.5	75.0
Average	35	17.5	17.5	92.5
High	11	5.5	5.5	98.0
Very High	4	2.0	2.0	100.0
Total	**200**	**100.0**	**100.0**	

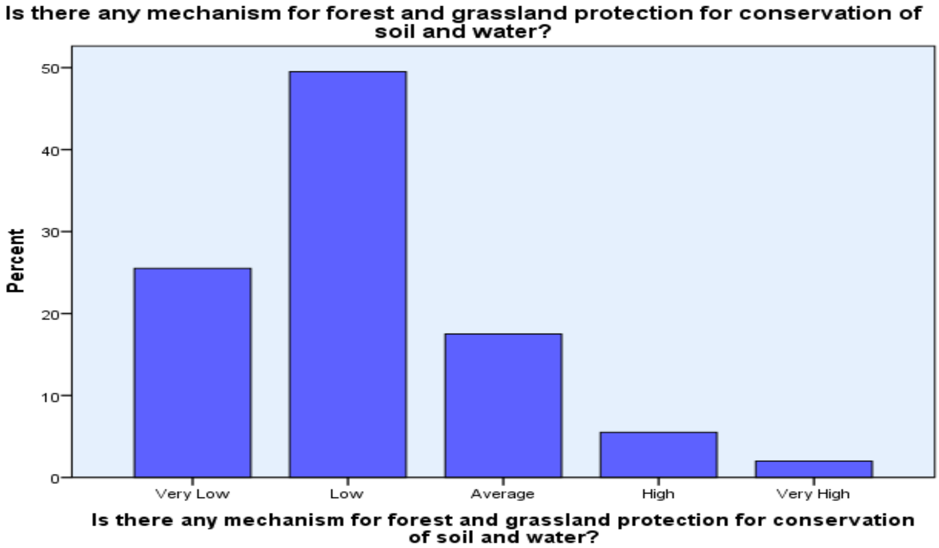

Figure 4. 27 Soil and Water Conservation

4.5.9 Slope Stabilization

Slope stability is the mechanism of reducing unstable slopes to stop initiation of landslide movements, which otherwise turn into landslide activity upon minor earthquake, mining or other disturbances. The report highlighted very less respondents in favour of the presence of any control mechanism for the underlying unstable slopes.

Table 4. 28 Slope Stabilization

Response	Frequency	Percent	Valid Percent	Cumulative Percent
Very Low	69	34.5	34.5	34.5
Low	88	44.0	44.0	78.5
Average	31	15.5	15.5	94.0
High	10	5.0	5.0	99.0
Very High	2	1.0	1.0	100.0
Total	**200**	**100.0**	**100.0**	

Figure 4. 28 Slope Stabilization

4.5.10 Engineering Applications i-e Check Dams, Dykes, Soil Bio-Engineering Techniques, Biological Measures i-e Reforestation, and Social Measures i-e Reduction of Human Disturbance

80 percent of the area deprived from the engineering applications, soil bio engineering techniques, biological measures and social measures as depicted by the survey conducted.

Table 4. 29 Engineering Applications, Soil Bio-Engineering Techniques, Biological Measures and Social Measures

Response	Frequency	Percent	Valid Percent	Cumulative Percent
Very Low	90	45.0	45.0	45.0
Low	69	34.5	34.5	79.5
Average	33	16.5	16.5	96.0
High	6	3.0	3.0	99.0
Very High	2	1.0	1.0	100.0
Total	**200**	**100.0**	**100.0**	

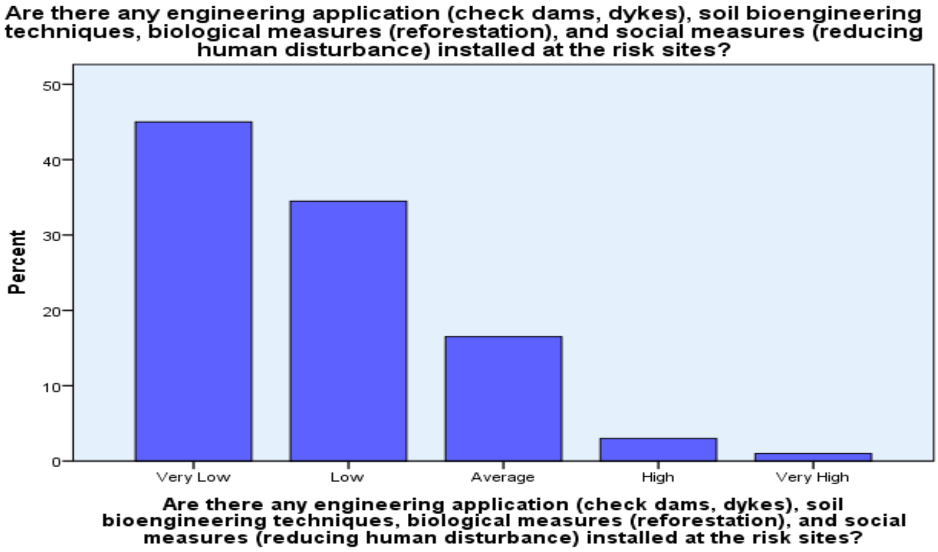

Figure 4. 29 Engineering Applications, Soil Bio-Engineering Techniques, Biological Measures and Social Measures

4.5.11 Debris Flow Breakers

The reports were totally unsatisfactory in this regard. 85 percent responses were in low and very low in this aspect.

Table 4. 30 Debris Flow Breakers

Response	Frequency	Percent	Valid Percent	Cumulative Percent
Very Low	109	54.5	54.5	54.5
Low	62	31.0	31.0	85.5
Average	24	12.0	12.0	97.5
High	3	1.5	1.5	99.0
Very High	2	1.0	1.0	100.0
Total	**200**	**100.0**	**100.0**	

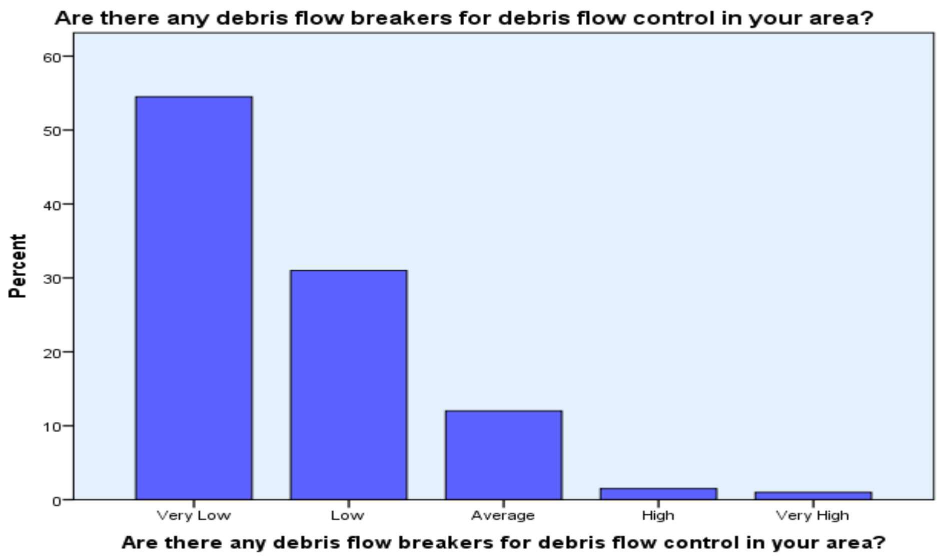

Figure 4. 30 Debris Flow Breakers

4.5.12 Drainage Mechanism

Rain water infiltration causes instability in the underlying rocks. According to report, the respondents denied to have proper drainage mechanism for concentrated water infiltration. More than 80 percent of the responses were in negative.

Table 4. 31 Drainage Mechanism

Response	Frequency	Percent	Valid Percent	Cumulative Percent
Very Low	88	44.0	44.0	44.0
Low	75	37.5	37.5	81.5
Average	30	15.0	15.0	96.5
High	6	3.0	3.0	99.5
Very High	1	.5	.5	100.0
Total	**200**	**100.0**	**100.0**	

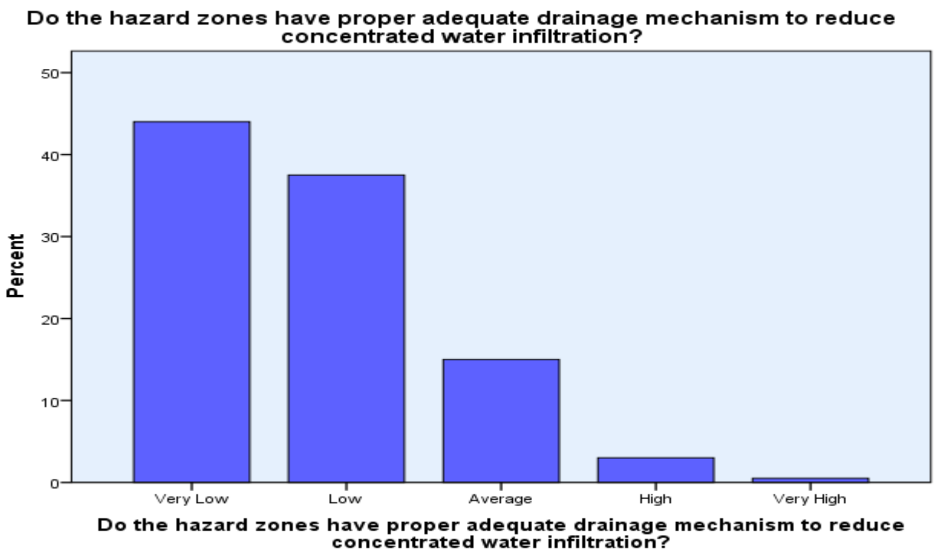

Figure 4. 31 Drainage Mechanism

4.5.13 Training/Awareness Programs on Landslide and Debris Flow

The survey identified 60 % of the people totally deprived from trainings/Awareness programmes and 31.5 % of the responders having average participation. However, it is considered a basic requirement as per the five priorities of the Hyogo Framework HFA Worldwide (Priority No. 3. Use knowledge, innovation and education to build a culture of safety and resilience at all levels). This portrayed that the level of mitigation measures has not being even introduced to the community in general.

Table 4. 32 Training/Awareness Programs

Response	Frequency	Percent	Valid Percent	Cumulative Percent
Very Low	51	25.5	25.5	25.5
Low	68	34.0	34.0	59.5
Average	63	31.5	31.5	91.0
High	15	7.5	7.5	98.5
Very High	3	1.5	1.5	100.0
Total	**200**	**100.0**	**100.0**	

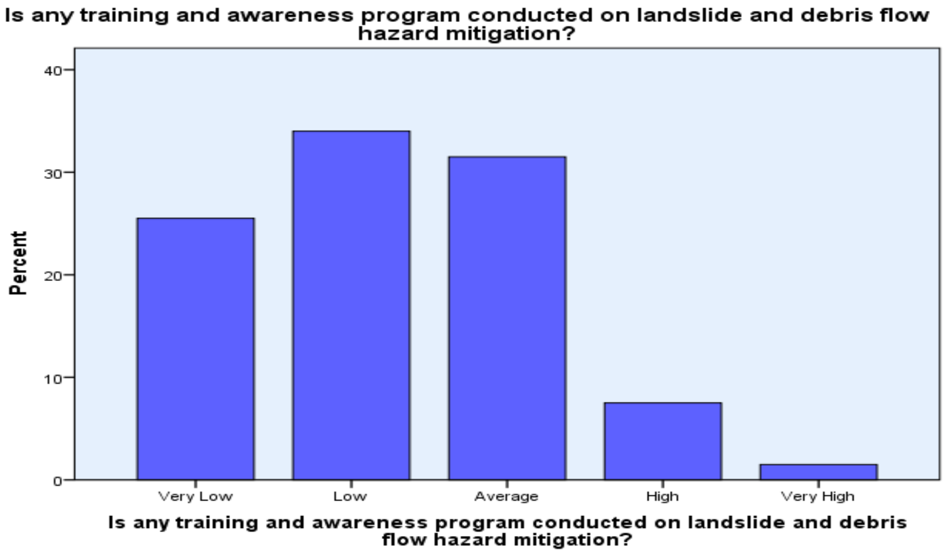

Figure 4. 32 Training/Awareness Programs

4.5.14 Participation of Community in Training/awareness Initiatives

To boost up the participation of community people in any programmes require introduction of that initiative/program to community at broad level. Nearly 50 percent of the respondents opted for very low and low as per the set parameters in this area.

Table 4. 33 Participation of Community

Response	Frequency	Percent	Valid Percent	Cumulative Percent
Very Low	33	16.5	16.5	16.5
Low	62	31.0	31.0	47.5
Average	73	36.5	36.5	84.0
High	23	11.5	11.5	95.5
Very High	9	4.5	4.5	100.0
Total	**200**	**100.0**	**100.0**	

Figure 4. 33 Participation of Community

4.5.15 Community Cooperation in Disaster Events

In times of disaster and emergency, cooperation of community is considered as an essential need. The hazardous events have very high probabilities of causing psycho-traumatic behavioral illnesses. The local community can be the first to responds and receiver of first aid services in that harsh situation. More than 40 percent of the respondents responded negatively as revealed by the study.

Table 4. 34 Community Cooperation in Disaster Events

Response	Frequency	Percent	Valid Percent	Cumulative Percent
Very Low	33	16.5	16.5	16.5
Low	54	27.0	27.0	43.5
Average	70	35.0	35.0	78.5
High	28	14.0	14.0	92.5
Very High	15	7.5	7.5	100.0
Total	**200**	**100.0**	**100.0**	

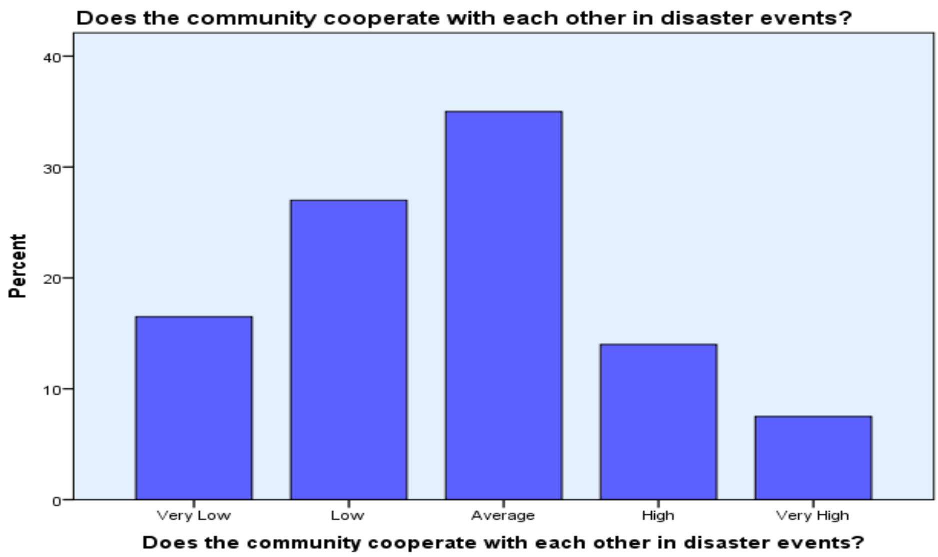

Figure 4. 34 Community Cooperation in Disaster Events

4.5.16 Hazard and Risks Assessments

Risks assessments is a multidisciplinary process, rather than an activity, that allow for the identifications, quantifications and understandings of the nature and extent, and impact of the risk a community or society is facing, which are linked with un-anticipated extreme event and the vulnerabilities of the exposed community or society. As per the survey conducted in this regard, only 7.5 percent of the responses were positive. This depicts the capacity of the concerned authority and their willingness to work out for building community resilience against landslide and debris flow disaster.

Table 4. 35 Hazard and Risk Assessment

Response	Frequency	Percent	Valid Percent	Cumulative Percent
Very Low	49	24.5	24.5	24.5
Low	81	40.5	40.5	65.0
Average	55	27.5	27.5	92.5
High	14	7.0	7.0	99.5
Very High	1	.5	.5	100.0
Total	**200**	**100.0**	**100.0**	

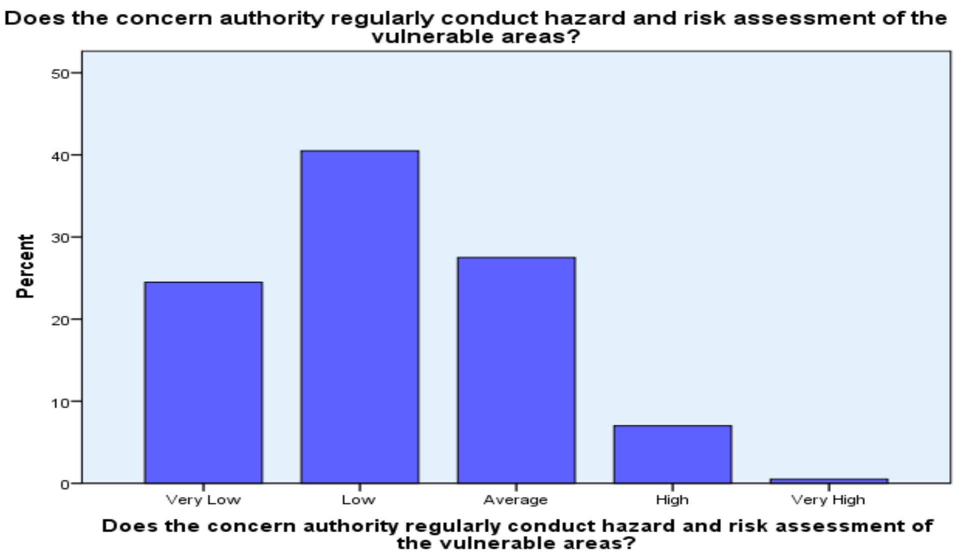

Figure 4. 35 Hazard and Risk Assessment

4.5.17 Identification of High Risk Geographical Areas

On asking about the identification of high risk area and communities, 70 percent of the responses were against in this aspect.

Table 4. 36 Identification of High Risk Geographical Areas

Response	Frequency	Percent	Valid Percent	Cumulative Percent
Very Low	61	30.5	30.5	30.5
Low	79	39.5	39.5	70.0
Average	49	24.5	24.5	94.5
High	10	5.0	5.0	99.5
Very High	1	.5	.5	100.0
Total	**200**	**100.0**	**100.0**	

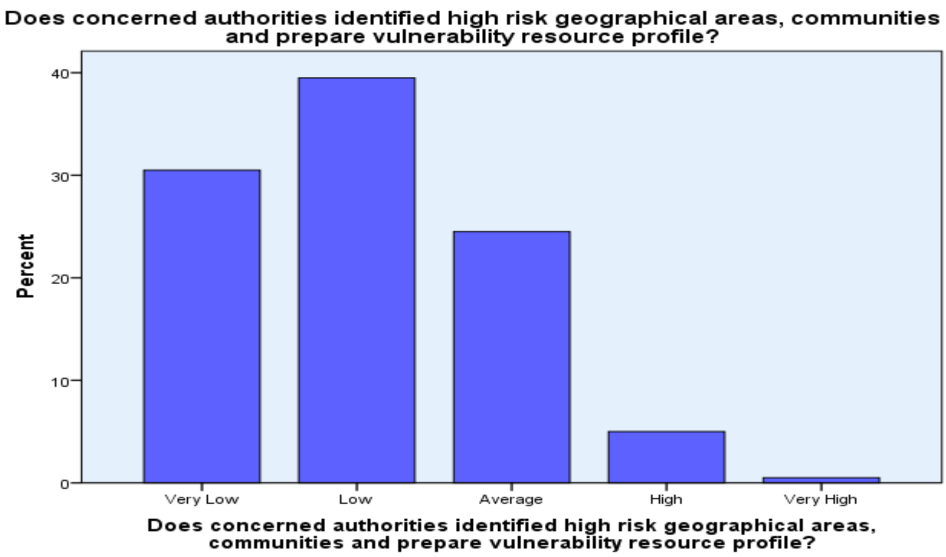

Figure 4. 36 Identification of High Risk Geographical Areas

4.5.18 Risk Sites Known to Community

Nearly 70 percent respondents answered very low and low as per the survey.

Table 4. 37 Risk Sites Known to Community

Response	Frequency	Percent	Valid Percent	Cumulative Percent
Very Low	57	28.5	28.5	28.5
Low	77	38.5	38.5	67.0
Average	49	24.5	24.5	91.5
High	16	8.0	8.0	99.5
Very High	1	.5	.5	100.0
Total	**200**	**100.0**	**100.0**	

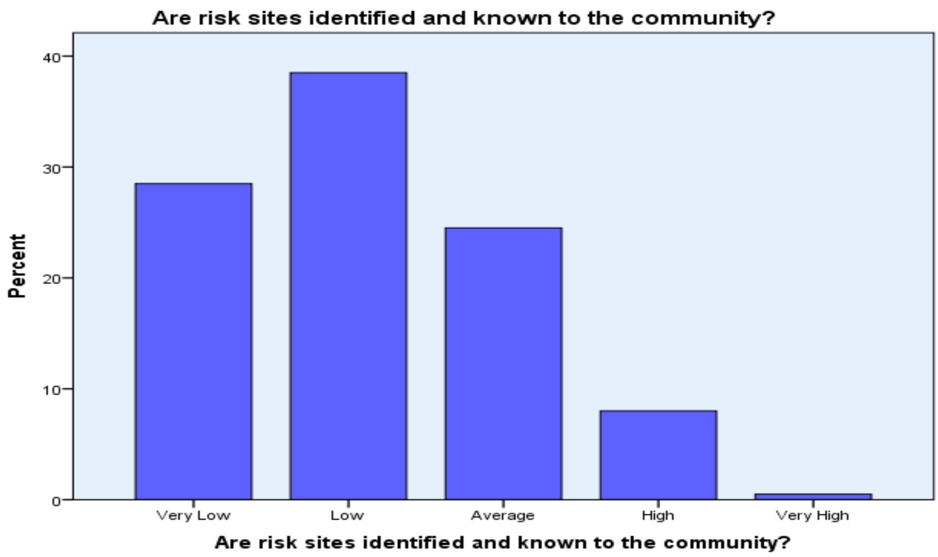

Figure 4. 37 Risk Sites Known to Community

4.5.19 Development of Search and Rescue and Emergency Response Teams

Saving human lives is of great concern and significance. That is why it is necessary to provide first aid facilities on the spot. Rescuing lives will enhance resilience of the community people. The development of such organized search and rescue and emergency response teams has not been established till now, but the local people provide their services in rescuing lives when such incident happens. It is further added that establishment of KP, Rescue 1122 is in progress on district level.

Table 4. 38 Development of Search and Rescue and Emergency Response Teams

Response	Frequency	Percent	Valid Percent	Cumulative Percent
Very Low	59	29.5	29.5	29.5
Low	78	39.0	39.0	68.5
Average	44	22.0	22.0	90.5
High	17	8.5	8.5	99.0
Very High	2	1.0	1.0	100.0
Total	**200**	**100.0**	**100.0**	

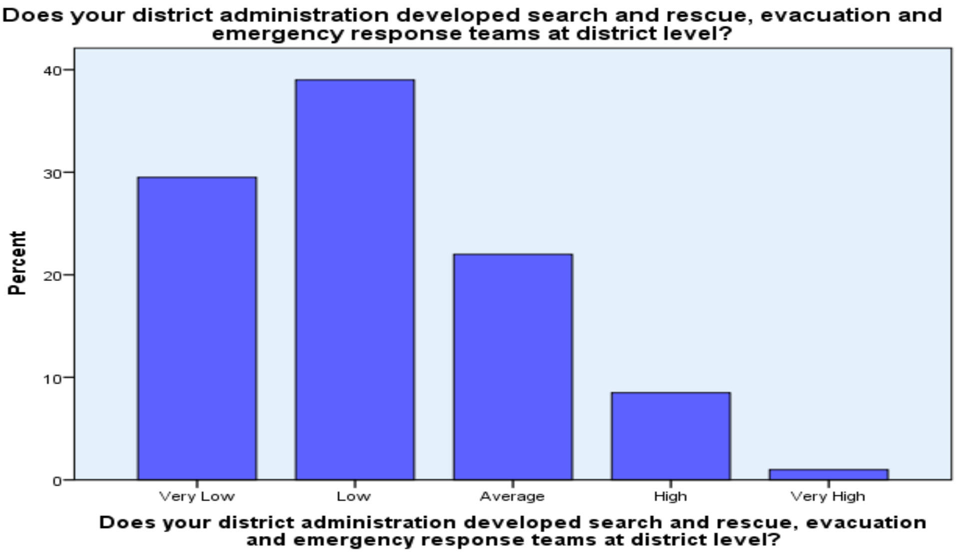

Figure 4. 38 Development of Search and Rescue and Emergency Response Teams

4.5.20 Regulations of New Settlements near Active sites

After proper Hazard and Risk Assessment of the vulnerable area, it is necessary to set regulations for the new settlements around disaster prone areas to minimize the losses in future. As per the study results, the respondents denied for such regulations.

Table 4. 39 Regulations of New Settlements near Active sites

Response	Frequency	Percent	Valid Percent	Cumulative Percent
Very Low	56	28.0	28.0	28.0
Low	71	35.5	35.5	63.5
Average	57	28.5	28.5	92.0
High	13	6.5	6.5	98.5
Very High	3	1.5	1.5	100.0
Total	**200**	**100.0**	**100.0**	

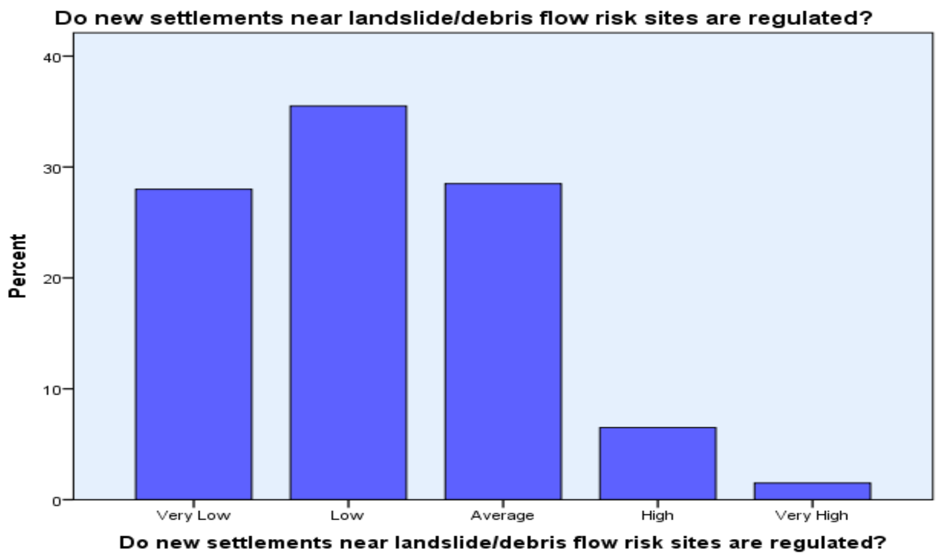

Figure 4. 39 Regulations of New Settlements near Active sites

4.6 SEMI-STRUCTURED INTERVIEWS OF CONCERNED DEPARTMENTS

A critical review of all the concerned departments has been done through Questionnaire based interviews for building community resilience against landslide and debris flow hazard. These questionnaires were made to assess the capacity of the line departments working in Hazard/risk reduction mainly to assess the emergency early warning mechanism, development of pre and post risk reduction measures at district level. Some major points discussed and noted down during interview with officials of the concerned departments. To highlight weak/grey areas of the departments, shortcomings were identified during the analysis. Basing on the results, conclusions and recommendations have been presented in the next chapter.

4.6.1 DISTRICT DISASTER MANAGEMENT AUTHORITY

The District Disaster Management Office (Dassu) of District Kohistan Upper and District Disaster Management Office (Pattan) of Kohistan Lower were consulted for inquiring their role in building community resilience to landslide and debris flow hazard. The offices were interviewed for Early Warning Mechanism and development of DRR measures in the study area.

4.6.1.1 District Disaster Management Office (Dassu)

Upon inquiring about the monitoring and early warning mechanism for landslides and debris flows hazards in the area, the responses were disappointing from the district disaster management office. The response from DDMO about conduction of trainings and awareness programs was not satisfactory and they arrange trainings and awareness programs on rare basis when the area is stricken by an imminent disaster having mass casualty. Participation of public is associated with the introduction of such trainings and mock exercises by the concerned authorities. Contingency plans were present but were out-dated.

On asking about implementation of Disaster Risk Reduction measures against landslide/ debris flow hazard, the responses were not satisfactory in any aspect. According to DDMU in charge, they have no hazard and risk assessment of the vulnerable areas. Only satisfactory responses were that the risk sites are identified and known to the community and they have planned relocation of communities to safer places from hazard sites. The DDMU Office added that they have developed search and rescue, evacuation and emergency response teams at district level for timely response in case of a landslide or debris flow activity. The District Emergency Operation Centre (DEOC) is activated in emergency and warns all line departments to remain alert for emergency response. The office prepare detailed plan for the resources requirement for relief operations and share it with the PDMA and NDMA.

Identification of Shortcomings

A total reactive approach was adopted by the district disaster management office which shows the resilience capacity of the department itself. Multi Hazard Vulnerability and Risk Assessment were not conducted for the prone area. Contingency plans were obsolete and not up to date with time. Community level trainings/ mock drills/ simulation exercises were not conducted. Record keeping mechanism of resources and volunteers was not updated.

4.6.1.2 District Disaster Management Office (Pattan)

As District Kohistan Lower is a newly established district, the DDMO Pattan is not functioning properly. The early warning mechanism is not developed and no DRR measures were taken in this regard. They lack human resource, financial resources and political interest.

4.6.2 PAKISTAN RED CRESCENT SOCIETY (PRCS)

For assessing the role of PRCS for building community resilience against landslide and debris flow disaster, a detailed interview was conducted with DDMO, PRCS Kohistan Branch. The following is the elaboration of the role of PRCS.

Communities at risk are mobilized and local level capacities are promoted and adopted for early warnings, preparedness and response. Trainings and other essential equipment for enhancing resilience of public to landslide/ debris flow are given to needy and vulnerable communities. Efforts are done for establishing Community Based Organizations (CBOs) and village disaster management committees in various union councils. Assistance is provided to district and tehsil administrations in time of needs.

PRCS facilitates local authorities in relief operations, camps establishment and food distribution after a landslide/ debris flow event in the area. Information management centers are established at relief and evacuation centers for the support of affected people, which are working in close coordination with other stakeholders.

The PRCS worked in collaboration with District Administration, Frontier Works Organization, general public and other relevant stakeholders on various projects for landslides and debris flow disasters in Kohistan. Upon inquiring about the major reasons of landslides and debris flows risk zones in Kohistan area, he pointed out the steep slope area, heavy raining, deforestation, heavy blasting by Chinese Construction Companies at Dassu Hydro Power Project (DHPP) area and vibration by movement of heavy vehicles. For mitigation of landslide and debris flow hazard, the PRCS share their contributions to district government. They suggests plantation, construction of tunnels on risk zones, adoption of precautionary measures by construction companies on DHPP and construction of check dams at risk zones. He further added that PRCS has a special volunteer task force/ pool i-e District Disaster Response Teams (DDRTs), Tehsil Disaster Response Teams (TDRTs) and Community Disaster Response Teams (CDRTs) for emergency response after landslide/debris flow disaster.

Identification of Shortcomings

The role of PRCS is exemplary for other departments but still there are few things which needed to be mainstreamed in PRCS working agenda.

PRCS is an international organization and have expertise in DRR. Multi hazard Vulnerability and Risk Assessment (MHVRA) for landslide and debris flow hazard at various levels according to the standard procedure were missing.

4.6.3 FOREST DEPARTMENT

Deforestation is an environmental hazard substantially affects the distribution and conservation of forest resources. The depletion rate of forest in Pakistan is very high and deforestation hazard is becoming a considerable environmental problem for Pakistan. Deforestation is the main agent in aggravating erosion, landslide and debris flow risk. The forest department was inquired in order to assess the deforestation surveillance system and BTAP plantation initiative. The surveillance system is very active in the whole district and plantation was carried out in landslides and debris flow hazards zones to provide support for the degraded land.

Identification of Shortcomings

Forests degradations need to be handle with as top priorities to form basis for a disasters resilient community. Community people should involve in forest management as they can play a key role in efficient implementation of any plan and without their consent forest management seems to be ineffective. Policies for forest preservation should be incorporated on priority basis and afforestation drives should be carried out on degraded land of main Karakoram highway to make community resilient to landslide and debris flow.

4.6.4 FRONTIER WORKS ORGANIZATION

Frontier works organization (FWO) was approach to inquire about their role in building communities resilience to landslides and debris flows disasters in the area. Their response was positive in contributing towards safe and resilient communities and passengers by assigning signboards and billboards about rock sliding in active slides areas. They also built culverts and drainage channels for rain water evacuation on main KKH. They clear the debris after landslide or debris flow activity on main transportation route in the area.

Identification of Shortcomings

Development projects must ensure soil and rock conservation mainly in areas prone to landslide and debris flow risks.

Chapter 5

FINDINGS, CONCLUSION AND RECOMMENDATIONS

5.1 RATIONALE OF THE CHAPTER

This chapter summarizes the findings of the study. Beside this it also provides conclusion in light of data analysis done on the basis of questionnaire and interviews. Recommendations are given on the basis of shortcomings identified at the end of this chapter.

5.2 FINDINGS OF THE STUDY

- No proper mechanism of dissemination of early warnings information for landslide/debris flows disaster was present in the area. The concerned authorities have no proper landslide/debris flow monitoring and early warnings systems.
- No proper DRR measures against landslide/debris flow hazard were in place by the concern authority at the hazard sites.
- Hazard and Risk Assessment was missing and people were not given a chance to participate in planning process or seeking solution of the issues communities face.
- Lack of legislation, lack of budget, lack of DRR experts, lack of political interest and lack of support from local people are the key hurdles in building resilience of communities to landslides and debris flows hazard in the area.
- The role of Pakistan Red Crescent Society (PRCS), Kohistan Branch was satisfactory and appreciable. A special volunteer task force/pool i-e District Disaster Response Teams (DDRTs), Tehsil Disaster Response Teams (TDRTs) and Community Disaster Response Teams (CDRTs) for emergency response after landslide/debris flow disaster was developed by PRCS Kohistan branch. PRCS was playing a very good and active role in building community resilience for landslide and debris flow hazard in Kohistan district.
- It was found that forest department role was crucial by planting Billion Tree Afforestation Project in consideration with mitigation of landslides and debris flows hazard in the areas. The outcome of the BTAP will be felt in next few years.

5.3 CONCLUSION

The study assessed the community resilience against landslide and debris flow hazard in Kohistan district.

- The initiatives for DRR in district Kohistan are found to be underfunded and under staffed with lack of administrative mechanisms and coordination at grassroots level.
- DRR interventions at the community level are reactive in nature with level of awareness and concept of resilient communities still in its rudimentary stages. There is no mechanism for capacity building of vulnerable communities, risk financing, and DRR expertise.
- Sharing of information and communication practices with community from the authority is centralized with less focus on local capacity building.

5.4 RECOMMENDATIONS

In order to build community resilience to landslide and debris flow hazard, some realistic recommendations are stated below;

- All development initiatives must include the component of Multi Hazard Vulnerability and Risk Assessment (MHVRA) to ensure land use planning and zoning regulations. This must be strictly implemented by TMA defining the high risk areas.
- Specialized DRR expertise/ human resource, funds, building infrastructure and equipment should be provided to DDMUs. Ware houses should be established at district and tehsil level for storing Non Food Items (NFIs).
- Predefined mechanism for activation of District Emergency Operation Center (DEOC) should be established with clearly defined roles and responsibilities of all stakeholders.
- Regular trainings/ mock exercises and awareness programs should be organized at district, tehsil, town and union council level to create general awareness regarding use of siren for early warning, issuance of warning through masjids, community center, TV cable networks, local newspaper and other available means of communications.

- Safe evacuations places and community centers should be identified and known to the community and record be maintained by the respective Tehsil Municipal Administration.
- There should be search and rescue and emergency response teams at tehsil level with facility of mobile and static health facilities and paramedics. Budget should be allocated to disaster management in annual budget of district and tehsil council.
- PRCS is a world class organization and is full of experts in DRR. PRCS should conduct Multi hazard Vulnerability and Risk Assessment (MHVRA) at various levels according to the standard procedure. Beside this, PRCS should help local authorities in preparation of district and tehsil wise disaster management plans for combating landslide and debris flow.
- The linkage and trust between local communities and the government agencies should be made stronger. Local people should be given chance in planning and other necessary tasks to build a sense of ownership.
- Policies for forest preservation should be incorporated on priority basis and afforestation drives should be carried out on degraded land of main Karakoram highway to make community resilient to landslide and debris flow.

References

Sost Today. (2016, April 6). Gilgit Baltistan, Pakistan.

Dawn. (2019, January 16). Kohistan, Khyber Pakhtukhwa, Pakistan.

Times of Islamabad. (2019, January 22). Kohistan, Khyber Pakhtunkhwa, Pakistan.

Abebe, B., Dramis, F., Fubelli, G., Umer, M., & Asrat, A. (2010). Landslides in the Ethiopian highlands and the Rift margins. *Journal of African Earth Sciences*, 8.

Amjad, A., & A. (2004-2005). Cost Benefit Analysis for Construction Projects. *IEP- SAC Journal*, 85-90.

Arain, F. M., & Low, S. P. (2005). Lesson learned from past projects for effective management of variation orders for Institutional Building Projects, Proceedings of the MICRA 4th Annual Conference, Kuala Lumpur, Malaysia.

Bell, J. (2005). Doing Your Research Project: A Guide for First Time Researchers in Education, Health and Social Science. *Maidenhead Open University Press*.

Bhasin, R., Grimstad, E., & Larsen, J. O. (2002). Landslide hazards and mitigation measures at Gangtok, Sikkim Himalaya. *Engineering Geology*, 18.

Bryman, A. (2004). Social Research Methods. *Oxford, Oxford University Press, London, UK*.

Clerici, A. e. (2010). Landslide failure and runout susceptibility in the upper T. Ceno valley (Northern Apennines, Italy. *Nat Hazards*, 29.

Comiti, F., Macconi, P., & Marchi, L. (2010). Debris flow mointoring and warning system, a new study site in the Alps. *EUROPEAN COMMISSION – WFD COMMON IMPLEMENTATION STRATEGY*, 10.

Crosta, G. B., & Frattini, P. (2001). Rainfall thresholds for triggering soil slips and debris flow. *Researchgate*, 24.

Dahal, R. K., & Hasegawa, S. (2008). Representative rainfall thresholds for landslides in the Nepal Himalaya. *Geomorphology*, 15.

Dai, F. C., Lee, C. F., & Ngai, Y. Y. (2002). Landslide risk assessment and management: an overview. *Engineering Geology*, 23.

Dai, F., Lee, C., & Ngai, Y. (2002). Landslide risk assessment and management: an overview. *Engineering Geology*, 23.

Dongtao, M., Jianjun, T., Peng, C., & Ruren, L. (2004). Approach to Mountain Hazards in Tibet, China. *Journal of Mountain Science*, 11.

Easterby, S., Thorpe, R., & Lowe, A. (1991). Management Research: An Introduction. *Sage Publications, London, UK*.

(n.d.). *EM-DAT. The OFDA/CRED International Disaster Database.*

Fowze, J., Bergado, D., Soralump, S., Voottipreux, P., & Dechasakulsom, M. (2012). Rain-triggered landslide hazards and mitigation measures in Thailand: From research to practice. *Geotextiles and Geomembranes*, 15.

Ho, M., Shaw, D., & Lin, S. (2008). How do disaster characteristics influence risk perception? *Risk Anal*, 8.

Holcombe, E. A., & Anderson, M. G. (2010). *Sustainable Development*, 18.

Holcombe, E. A., & Anderson, M. G. (2010).

Hughes, R. (1982). The effects of flooding upon buildings in developing countries. *Disasters*, 10.

Kaleela, M. M., & Reezab, M. R. (2017). The Impact of Landslide on Environment and Socio-Economy: GIS Based Study on Badulla District in Sri Lanka. *World Scientific News*, 15.

Kamp, U. e. (2010). Back analysis of landslide susceptibility zonation mapping for the 2005 Kashmir earthquake: an assessment of the reliability of susceptibility zoning maps. *Nat Hazards*, 25.

Karen et al. (2012). A case study of coping strategies and landslides in two villages of Central-Eastern Nepal. *Applied Geography*, 11.

Kazmi, A., & Jan, M. (1997). Geology and tectonics of Pakistan. *Graphic publishers, Karachi*.

Khan, A. (1992). Housing and landslides: a case study of Murree, Pakistan. *University of Nottingham, UK*.

Khan, A. (1994). Towards an appraisal of landslide hazard reduction programme in Murree, Pakistan. *Pak J Geogr*, 15.

Khan, A. (2000). Landslide hazard and policy response in Pakistan: a case study of Murree, Pakistan. *Sci Vis*, 14.

Khan, A., & Atta-ur-Rahman. (2006). Landslide hazards in the mountainous region of Pakistan. *Pak J Geogr*, 13.

Khattak, G. A., Owen, L. A., Kamp, U., & Harp, E. L. (2010). Evolution of earthquake-triggered landslides in the Kashmir Himalaya, northern Pakistan. *Geomorphology*, 7.

Kish, L. (1995). Survey Sampling. *Wiley Interscience*.

Li, C. e. (2010). aiNet- and GIS-based regional prediction system for the spatial and temporal probability of rainfall-triggered landslides . *Nat Hazards*, 21.

Lu, P.-L. (2014). Using multiple vegetation layers to reduce the risk of rainfall-induced landslides and facilitate post-landslide slope rehabilitation. *Access International Journals*, 4.

Marchi, L., Arattano, M., & Deganutti, A. M. (2002). Ten years of debris-flow monitoring in the Moscardo Torrent (Italian Alps). *Geomorphology*, 17.

Marsh, C. (1982). The Survey Method, The Contribution of Surveys to Sociological Explanation. *Allen and Unwin*, .

Mikoš, M., & Majes, B. (2014). Mitigation of Large Landslides and Debris Flows in Slovenia, Europe. *ResearchGate*, 27.

Miller, K. (1984). The international Karakuram project-1(ed). In: Proceedings of the international conference, Islamabad. *Cambridge University Press, Cambridge*.

Msilimba, G. (2010). The socioeconomic and environmental effects of the 2003 landslides in the Rumphi and Ntcheu Districts (Malawi). *Nat Hazards*, 14.

Nadim, F., Kjekstad, O., & Peduzzi, P. (2006). Global landslide and avalanche hotspots. *Landslides*, 14.

Nakileza, B. R., Majaliwa, M. J., & Wandera, A. (2017). Enhancing resilience to landslide disaster risks through rehabilitation of slide scars by local communities in Mt Elgon, Uganda. *Jamba: Journal of Disaster Risk Studies*.

Neuhäuser, B., Papathoma-Köhle, M., & Ratzinger, K. (2007). Elements at risk as a framework for assessing the vulnerability of communities to landslides. *Nat Hazard Earth Eys*, 15.

Niederer, S., & Schaffiner, U. (1988). Landslide problems and erosion control in Murree and Kahuta Tehsils of Rawalpindi District. *Report of the fact finding mission, June 1988, SDC, Ministry of Foreign Affairs, Government of Switzerland, CH-3003 BERN*.

Owen, e. (2008). Landslides triggered by the October 8, 2005, Kashmir earthquake. *Geomorphology*, 9.

Pasuto, A., & Soldati, M. (2004). An integrated approach for hazard assessment and mitigation of debris flows in the Italian Dolomites. *Geomorphology*, 11.

Ramesh, M. V. (2014). Design, development, and deployment of a wireless sensor network for detection of Landslide. *Ad Hoc Networks*, 18.

Root, D., Fellows, R., & Hancock, M. (1997). Quantitative versus Qualitative or Positivism and Interactionism- A reflection of ideology in the Current Methodological Debate. *Journal of Construction Procurement*, 12.

Santha, S. D., & Sreedharan, R. K. (2010). Population vulnerability and disaster risk reduction: A situation analysis among the landslide affected communities in Kerala, India. *JAMBA: Journal of Disaster Risk Studies*, 14.

Saunders, M., Lewis, P., & Thornhill, A. (2003). Research Methods for Business Students. *Harlow FT Prentice Hall*.

Seymour, D., & Rooke, J. (1995). The Culture of the Industry and the Culture of Research. *Construction Management and Economics*, 13.

Seymour, D., Crooke , D., & Rooke, J. (1997). The Role of Theory in Construction Management: A Call for Debate. *Construction Management and Economics*, 3.

Shuwei, W. (2009). The Impact of Collaborative Working on Construction Project Performance. *University of Northumbria, Newcastle*.

Solana, M., & Kilburn, C. (2003). Public awareness of landslide hazards. *Geomorphology*, 10.

Trochim, W., & M., K. (1997). The Research Methods Knowledge Base.

Wan, S. e. (2010). A novel data mining technique of analysis and classification for landslide problems. *Nat Hazards*, 20.

Wang, C., Esaki, T., Xie, M., & Qiu, C. (2006). Landslide and debris-flow hazard analysis and prediction using GIS in Minamata–Hougawachi area, Japan. *Springer*, 12.

Yu, G.-a., Huang, H. Q., Wang, Z., Brierley, G., & Zhang, K. (2012). Rehabilitation of a debris-flow prone mountain stream in southwestern China- Strategies, effects and implications. *Journal of Hydrology*, 13.

APPENDIX: QUESTIONNAIRES

a. Community Survey

b. Departmental Survey

FIELD SURVEY FOR

ANALYSIS OF COMMUNITY RESILIENCE TO LANDSLIDE AND DEBRIS FLOW HAZARDS IN KOHISTAN DISTRICT

THE STUDENT:

AURANG ZEB

MS Disaster Management

Advisor:

Dr. Arshad Ali

QUESTIONNAIRES

(Community Survey)

Survey for Master's Thesis

Thesis Topic: Analysis of Community Resilience to Landslide and Debris Flow Hazards in Kohistan District

General Information (Will Not be Published)	
Name	
Gender	
Age	
City	
Profession	
Designation	

Q. No.	**Questions**	**Response**				
		Very Low	**Low**	**Average**	**High**	**Very High**
		1	**2**	**3**	**4**	**5**
General Information						
1.	Do you have any prior knowledge about landslide and debris flow hazard?					
2.	How many times have you witnessed/experienced this disaster?					
3.	What are common damages as a result of these disasters?					
4.	What is the first response of the community in case of a disaster event?					

5.	Is District Disaster Management Authority functional and working in your district?					
6.	Does the local authority support the community in times of disaster?					
7.	Do you feel any positive change after development of District Disaster Management Authority?					
Early Warning Information						
8.	Is prior warning regarding landslide and debris flow provided to you?					
9.	Was there any early warning system known to you from your forefather's time?					
10.	If 'Yes' how did it work?					
11.	How is information related to a disaster disseminated within the community?					
12.	Do concern authorities have monitoring and landslide warning system?					
13.	How much trust community has in the warnings issued to them?					
14.	Do you believe the warnings issued by local authorities?					
15.	How credible, reliable and authentic is the information disseminated by concern district authorities?					
16.	Do the community prepare for landslide and debris flow after dissemination of early warning information?					
Risk Reduction Measures						
17.	Are there any risk reduction measures					

	taken at the hazard site?					
18.	Is community educated and trained in dealing with disaster events?					
19.	Is there any planned relocation of community to safer places from hazard sites?					
20.	Is tree cutting checked in your area by authorities?					
21.	Is there any afforestation activities held under Khyber Pakhtunkhwa billion tree afforestation project in landslide and debris flow risk zones?					
22.	Are culverts and proper water channels are built for rain water disposal?					
23.	Is there any retaining wall and discharge tunnel for diversion of debris flow track built?					
24.	Is there any mechanism for forest and grassland protection for conservation of soil and water?					
25.	Is there any control mechanism of the underlying unstable slope to stop initiation of landslides and movement?					
26.	Are there any engineering application (check dams, dykes), soil bioengineering techniques, biological measures (reforestation), and social measures (reducing human disturbance) installed at the risk sites?					
27.	Are there any debris flow breakers for debris flow control in your area?					

28.	Do the hazard zones have proper adequate drainage mechanism to reduce concentrated water infiltration?					
29.	Is any training and awareness program conducted on landslide and debris flow hazard mitigation?					
30.	Does the community actively participate in such training and awareness initiatives?					
31.	Does the community cooperate with each other in disaster events?					
32.	Does the concern authority regularly conduct hazard and risk assessment of the vulnerable areas?					
33.	Does concerned authorities identified high risk geographical areas, communities and prepare vulnerability resource profile?					
34.	Are risk sites identified and known to the community?					
35.	Does your district administration developed search and rescue, evacuation and emergency response teams at district level?					
36.	Do new settlements near landslide/debris flow risk sites are regulated?					

SEMI-STRUCTURED INTERVIEWS
(Departmental Survey)

Survey for Master's Thesis

Thesis Topic: Analysis of Community Resilience to Landslide and Debris Flow Hazards in Kohistan District

District Disaster Management Authority

General Information (Will Not be Published)	
Name	
Gender	
Age	
City	
Profession	
Designation	

Q. No.	**Questions**	**Response**				
		Very Low	**Low**	**Average**	**High**	**Very High**
		1	**2**	**3**	**4**	**5**
1.	Do you have proper monitoring and early warning mechanism for landslide and debris flow hazards in your area?					
2.	Do community follow the early warning information issued to them?					
3.	How credible, reliable and authentic is the information disseminated by the concern district authorities?					

4.	Do you conduct trainings and awareness programs for landslide and debris flow mitigation?					
5.	Does the community actively participate in such training and awareness initiatives?					
6.	Do you have stockpiling of basic necessities and community knowledge about stockpiling?					
7.	Do you regularly conduct hazard and risk assessment of the vulnerable areas?					
8.	Have you identified high risk geographical areas, communities and prepare vulnerability resource profile?					
9.	Are risk sites identified and known to the community?					
10.	Is there any planned relocation of communities to safer places from hazard sites?					
11.	Do you develop any disaster risk reduction measure against landslide/debris flow risks?					
12.	Do you feel any positive change after risk reduction measure?					
13.	Do you promote indigenous system and practices for mitigating disaster at community level?					
14.	Have you developed search and rescue, evacuation and emergency response teams at district level?					
15.	Do you activate DEOC in emergency?					

16.	Do you warn all district level departments to get ready for emergency response?					
17.	Do you inform PEOC and NEOC about the situation?					
18.	Have you prepared detailed plan for the resources requirement for relief operation and share it with the PMDA and NDMA?					
19.	Is there any afforestation activities held under Khyber Pakhtunkhwa billion tree afforestation project in landslide and debris flow risk zones?					
20.	Do human activities and new construction forbidden and residents and buildings moved to safer places to minimize the losses?					
21.	Do any engineering application (check dams, dykes), biological measures (reforestation), soil bioengineering techniques and social measures (reducing human disturbance) installed?					
22.	Is there any debris flow breaker installed for debris flow control in the area?					
23.	Is there any inspection system of the catchment and documentation of the existing condition (e.g. channel, forest, slopes and mitigation measures)?					
24.	Do the hazard zones have proper adequate drainage mechanism to reduce concentrated water infiltration?					

SEMI-STRUCTURED INTERVIEWS

(Departmental Survey)

Survey for Master's Thesis

Thesis Topic: Analysis of Community Resilience to Landslide and Debris Flow Hazards in Kohistan District

Pakistan Red Crescent Society, Kohistan Branch

General Information (Will Not be Published)	
Name	
Gender	
Age	
City	
Profession	
Designation	

Q. No.	**Questions/Response**
1.	Do you have/worked on any project for landslide/debris flow disaster on main Karakoram Highway?
2.	What are the major reasons for active landslide/debris flow risk zones on this route?
3.	What kind of disaster risk reduction measures do you suggest for mitigating the above risks?
4.	Do you work in collaboration with district administration for combating landslide/debris flow risk?
5.	Do you have any volunteer task force for emergency response after landslide/debris flow event?

SEMI-STRUCTURED INTERVIEWS

(Departmental Survey)

Survey for Master's Thesis

Thesis Topic: Analysis of Community Resilience to Landslide and Debris Flow Hazards in Kohistan District

Forest Department

General Information (Will Not be Published)	
Name	
Gender	
Age	
City	
Profession	
Designation	

Q. No	**Questions**	**Response**				
		Very Low	**Low**	**Average**	**High**	**Very High**
		1	**2**	**3**	**4**	**5**
1.	Grade the overall importance of forests in combating disaster risks?					
2.	Do you have a surveillance system for deforestation activities?					
3.	Does deforestation a major reason in aggravating threats for landslides/debris flow hazard?					
4.	Do forest laws have local level implementation and forest policies are effective in combatting deforestation?					

5.	Community is involved and incentives are given to community for participation in forest management practices?					
6.	Forest authorities have sufficient resources to conserve forests for combating disaster risks?					
7.	Do forest management is carried out fairly and evaluated for progress in mitigating landslide/debris flow risks?					
8.	Does plantation carried out in landslide/debris flow prone sites under Khyber Pakhtunkhwa billion tree afforestation project?					

SEMI-STRUCTURED INTERVIEWS
(Departmental Survey)

Survey for Master's Thesis

Thesis Topic: Analysis of Community Resilience to Landslide and Debris Flow Hazards in Kohistan District

Frontier Works Organization

General Information (Will Not be Published)	
Name	
Gender	
Age	
City	
Profession	
Designation	

Q. No.	Questions	Response				
		Very Low	**Low**	**Average**	**High**	**Very High**
		1	**2**	**3**	**4**	**5**
1.	Signboards and billboards warning about slides of rocks and debris in landslide and debris flow risk sites?					
2.	Any counter measure for active slide area?					
3.	Development projects ensure soil and rock conservation in areas prone to landslide and debris flow risks?					

4.	Unplanned encroachment in hazard zone is strictly checked?					
5.	New settlements preserve soil and rock conservation under supervision of administration?					