Evaluation of Earthquake Risk Perception, Preparedness and Physical Vulnerability - A case study from Rawalakot, Pakistan

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Fall 2017- MS Structural Engineering

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Copyright Statement

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Abstract

Azad Jammu & Kashmir (AJ&K) is among the most earthquake-prone regions of the world. The 2005 Muzaffarabad earthquake ($\boldsymbol{M_w}$ 7.6) resulted in a massive destruction of the infrastructural facilities along with significant social loss. In order to develop effective strategies to reduce the social, environmental and economic losses from future destructive earthquakes, it is important to first assess the level of earthquake preparedness at household level in this region. Several studies have indicated that the level of seismic risk perception among a community may significantly influence their willingness to take preparedness measures. Some of the previous studies suggest that physical vulnerability and potential losses are highly associated. Therefore, this study aimed to evaluate a potential association between perceived risk and earthquake preparedness at household level in urban, peri-urban and rural area of Rawalakot – a district located in AJ&K. Physical vulnerability data was collected using Rapid visual screening techniques. Based on the Yamane method, 400 samples from urban, peri-urban, and rural study areas were collected using random sampling. Primary data was collected from face-to-face interviews using structured questionnaires. An index-based approach was used to find risk perception and preparedness indices. Risk perception was measured using fear, awareness, trust and attitude indicators. Descriptive statistics and a linear regression model were used to find the significant variance and relationship between risk perception and preparedness. The results revealed that risk perception is significantly influenced by fear of future earthquakes, expected breakdown of supplies, and expected damage of the houses. The study also found that risk perception and its various dimensions influence the earthquake preparedness. The relevant authorities can use the findings of this study to design comprehensive risk awareness and preparedness program at the household level. and socio-economic conditions of people.

Keywords: Azad Jammu & Kashmir, Risk perception, preparedness, Vulnerability, Structural design, Building code

Table of Contents

Table of figures

List of Tables

List of Abbreviations

NDMA	National disaster management authority
SDMA	State disaster management authority
ERRA	Earthquake reconstruction and rehabilitation authority
SERRA	State earthquake reconstruction and rehabilitation authority
PaK	Pakistan administrated Kashmir
DMS	Disaster management system
BCP	Building code of Pakistan
Mw	Magnitude
AJ&K	Azad Jammu & Kashmir
GIS	Geographical information system
RPI	Risk perception index
PI	Preparedness index
PVI	Physical vulnerability index
CR	Consistency ratio
CRED	Centre of research and epidemiology of disasters
RMMs	Risk mitigation measures
SNL	Sendia national laboratory
KPK	Khyber Pakhtunkhwa

1. INTRODUCTION

1.1 Background

Disasters are the events that bring human, economic, environmental and social loss on such a level that the affected people cannot cope up using their own resources. Disasters may be man-made or natural, progressive or sudden. According to study of Centre of Research on Epidemiology of Disasters (CRED) 2015, in last 20 years (between 1994 to 2013), 1.35 million people were killed by 6873 disasters globally [1]. Natural disasters include earthquake, floods, hurricanes and land slides etc. Out of these earthquake is the most devastating form of disaster as it occurs in a brief period of time causing huge loss of lives and infrastructure. Earthquakes can not be predicted like any other disaster which make them more destructive. Geologists agree that sometimes earthquakes trigger secondary disasters like tsunamis and landslides etc [2].

Earthquakes are unpredictable and unavoidable, so the efforts are being made to reduce the losses of lives, economy and environment using mitigation techniques. This is referred as Disaster risk reduction [2,3]. It is therefore necessary to have a strong knowledge of people risk perception, preparedness, vulnerability of their houses and their socio-economic conditions to develop the true mechanism for earthquake risk reduction. Earthquake risk reduced risk will result in reduction of all type of losses as a result of a disaster.

Azad Jammu & Kashmir (AJ&K) lies on boundaries of three tectonic plates, Arabic, Eurasian and Indian, which are moving with their own rate. This complex seismic environment makes these region seismically active and prone to earthquakes [4]. Due to northward drift of Indian plate and collision with Eurasian plate in past 120 years, six major earthquakes have been occurred, one of them is Kashmir 2005 earthquake [5]. Pakistan and Azad Jammu & Kashmir being administrated by Pakistan also lies in developing countries where poverty, weaker economy and less awareness has contributed to high physical vulnerability of the buildings and therefore high risk. Unplanned urbanization, poverty, unawareness leads to losses of lives and economy [6]. Improper construction without following bye-laws, structural design and building codes increase the vulnerability of building stock. A building with high vulnerability will be more exposed to the damage [7].

In Pakistan disaster studies was an ignored field. After the massive earthquake of 0ctober, 2005 government of Pakistan created different institutions for disaster management like NDMA, SDMA, ERRA and SERRA. But still these institutions use reactive approach against the disasters. There is no significant earthquake preparedness program in Pakistan on community level. The communities itself don’t have enough resources to cope up with. This incompetence of state institutions and less resilience of communities leads towards more damage [8]. Need is to improve the preparedness of the community against earthquakes and improvise government strategies to reduce the risk. Lack of serious efforts will result in unmatched damages from future earthquakes [9]. For this purpose thorough earthquake risk perception, preparedness studies and vulnerability assessment studies must be done to formulate better risk reduction strategies. Risk reduction in other way is disaster management.

Public risk perception can be defined as collection and interpretation of uncertain results of events or activities by the general public [10]. Risk can be perceived by direct experience of the situation or by getting information from other sources [11]. Awareness and risk perception are most crucial stages in process of protection against hazards. People from three (high, moderate and low) socio-economic profile were interviewed. Studies revealed that some people were calling the disaster as act of God which can’t be stopped. The risk perception is also related to socio-economic conditions [12]. The perceived risk for future damages was studied relative to the past earthquakes. People with past experience tend to rate the risk higher. Risk perception studies are important as they the depict the attitude of people towards risk. Such studies depict the response of individuals and their communities towards risk. It also explains their role in implementation of government policies like building code and other risk reduction strategies etc. Risk perception can be stated as a part of seismic vulnerability assessment [13]. Vulnerability assessment against seismic events gives suggestions to reduce vulnerability. So vulnerability assessment can be called as a part of disaster risk reduction or disaster risk management [14].

Physical vulnerability is associated with ability of building structures to withstand against impacts of earthquake or any other disaster. In regions prone to earthquake the stability of buildings is associated with structural behavior of buildings against ground motion. Buildings with plan and vertical irregularities showed poor performance in recent earthquakes. Varying stiffness and geometry makes the building more vulnerable. Such study of the buildings in a high building density area was done quickly using aerial photographs approach in GIS platform

[15]. Vulnerability can be higher even in low to moderate seismicity regions because of presence of older building stock that is usually unreinforced and constructed without considering earthquakes [16].

Seismic vulnerability of lifeline buildings was estimated in Himalayan province of India. It was found that majority of lifeline building will become dysfunctional after an earthquake because of substandard construction, lack of safety standards and low maintenance. Buildings can be classified on the basis of level of expected damaged Using results of physical vulnerability assessment, buildings can be classified on the basis of level of expected damage in case of any future earthquake [17]. Physically vulnerable building stock was classified into five grades starting from slight damage to total damage under the action of a future earthquake [18]. Physical vulnerability assessment is considered as a part of seismic risk assessment. Probable loss of building damage, infrastructure and economy can be estimated without knowing the vulnerability of building stock. So physical vulnerability plays a vital role in formulating seismic risk reduction strategies. Seismic risk reduction strategies are part of disaster management and these studies have been done in recent past in Pakistan [19].

Certain actions are taken that are proved to be effective against disaster are included in preparedness. Preparedness is effected by age, gender, knowledge and direct experience of a disaster [20, 21]. Preparedness among the individuals, their families and communities is essential in order to increase resilience against disaster. Media exposure and education has a positive impact on disaster preparedness. Disaster experience and risk perception also have relation with preparedness [22]. For better formulations of disaster risk reduction strategies it is necessary to understand psychological preparedness. Physical and mental health, education, awareness and past experience are associated with psychological preparedness [23].

These type of studies will play a vital role in mitigation of hazards and improvement of risk reduction strategies. As these studies require a lot of expertise and resources so these are limited in developing countries. Need of the hour is to accelerate the research to formulate better seismic risk reduction strategies.

Pakistan is a developing country with a lot of problems like unstable economy, poverty, increased rate of urbanization, mushroomed growth of housing societies and poor construction practices. Also the earthquakes are hitting Pakistan regularly. This increases the risk to a considerable extend [6]. Lack of awareness about seismic risk and less knowledge of building codes makes the situation worst. Government authorities are using Pro-active approach and also they don't have effective disaster risk reduction plans [24].

1.2 Problem Statement

Pakistan lies in a hazard prone region of the world. These hazards include tsunamis, earthquakes, floods and landslides etc. The history of natural disasters from 1954 to 2004 revealed that most occurring disasters in Pakistan is flood followed by earthquakes. The Quetta earthquake 1935 and Kashmir earthquake 2005 are recent examples of destructive earthquakes in Pakistan. According to Pakistan Meteorological department report, 58 damaging earthquakes have stroked Pakistan. These earthquakes resulted in damage including loss of more than 95000 lives and damage of thousands of buildings [25].

Azad Jammu & Kashmir being administrated by Pakistan has nearly the same situation about disaster risk and vulnerability. The building stock of the Indo-Pak region is highly vulnerable which is confirmed by the Kashmir 2005 earthquake [26]. National disaster management authority (NDMA) has kept many districts of Azad Jammu & Kashmir in zone 3 and 4 in risk maps. Based on peak ground acceleration (pga), zone 3 and 4 are high risk areas [27]. The earthquake of Kashmir 2005 resulted in more than 73000 causalities, 80000 injuries and made 0.28 million people homeless. Studies revealed that this huge loss is not only due to high seismic hazard but also due to vulnerability of buildings [26]. After huge losses in recent earthquake of Kashmir 2005, attention is being paid on vulnerability assessment studies to assist risk reduction strategies [8]. In case of any future earthquake, the high seismic zones of Pakistan will receive a huge loss of lives, cultural heritages and infra structure. Although the region lies in seismic zone but increased rate of urbanization and non-engineered construction also contributes to vulnerability [28]. It is also confirmed by the earthquake of Mirpur 2019 which resulted in mass destruction of highly vulnerable buildings.

Pakistan has history of strong earthquakes, and there is chance of further earthquakes in future. Studies should be conducted on seismic vulnerability assessment. Public risk perception and preparedness should be studied. These studies will aid to develop effective disaster risk reduction strategies. . Based on results of physical vulnerability studies of buildings different retro-fitting techniques can be proposed. This study tries to find public risk, preparedness, physical vulnerability of the residential units and their relationship. The area selected for this study is Rawalakot Azad Jammu & Kashmir, which is kept in Seismic zone 3 by Building code of Pakistan (BCP). According to District risk assessment matrix, earthquake was ranked as most threatening natural hazards. According to District disaster risk management plan Poonch 2017, 83% of houses were fully damaged and 15% were partially damaged. So this study is also important as a post-earthquake study of an area prone to earthquake [29].

In Pakistan risk reduction strategies are dealt on provincial level and top to bottom approach is used for their implementation. But studies have proved that earthquake risk perception, earthquake preparedness and physical vulnerability change with demographic factors [24]. So studies should be conducted to evaluate physical vulnerability, risk perception and preparedness on household level in the urban, peri-urban and rural study area.

1.3 Research Objectives

Objectives of studying perceived risk, preparedness and physical vulnerability of Rawalakot Azad Jammu & Kashmir (AJ&K) includes:

1. To analyze the dynamics of physical vulnerability in urban, peri-urban and rural settings.
2. To quantify the earthquake risk perception, preparedness measures and measure influence of earthquake risk perception on preparedness measures in earthquake prone communities.
3. To propose the influence of individual dimensions of earthquake risk perception (fear, awareness, trust, attitude) on the level of preparedness.
4. To measure the impact of physical vulnerability on risk perception in all the study areas.

1.4 Scope of the Study

AJ&K region is prone regular to seismic events, these events result in damage of physically vulnerable structures, resulting in casualties and other losses. Physical vulnerability is an important parameter that gives insight about capacity of existing buildings to withstand earthquake. So this research is helpful for building control authorities to further improve their bye-laws and regulations to increase the capacity of buildings and decrease their vulnerability. In case of highly vulnerable buildings authorities can recommend people for special retrofitting techniques or reconstruction.

Risk perception will help to know the level of awareness, trust on disaster management authorities and attitude of people towards earthquake. This part of study can help disaster management authorities to create awareness programs and disaster resilience programs. Preparedness has a key role in risk reduction. Preparedness increases resilience against disaster which is the ultimate goal. This part of study will help the relevant institutions to take steps for increasing preparedness measures against disaster. For this purpose they can establish local building codes for new constructions and special repair and retrofitting techniques for built structures.

1.5 Thesis Structure

The thesis has been divided into following chapters to achieve the above mentioned objectives.
Chapter 2, Literature review: this chapter explains the basic concepts of people risk perception, preparedness and physical vulnerability. It also includes the literature about research being carried out in Pakistan and other countries. The conclusions drawn by the previous studies are also discussed.

Chapter 3, Methodology: This chapter includes the detailed methodology adopted for reaching the objectives. This chapter is further categorized into sub-sections, which include description of the study area, sampling method and data collection, people risk perception method, preparedness perception method and physical vulnerability assessment along with statistical analysis to find their mutual relationship.

Chapter 4, Results and discussions: This chapter includes the results of risk perception index, physical vulnerability index and preparedness index for different study areas including urban, peri-urban and rural. This chapter also includes the influence of physical vulnerability on seismic risk perception. In the last section discussions are made on the results of the research. Objectives are discussed while relating them with socio-economic conditions.

Chapter 5, Conclusions and recommendations: This chapter includes summary of findings of the research. It compares the results of risk perception, preparedness and physical vulnerability for all the three zones, Urban, peri-urban and rural. In last section it gives recommendations about how to improve the people risk perception, increases preparedness and reduce physical vulnerability.

2. LITERATURE REVIEW

2.1 Background

Earthquakes are becoming an alarming issue over the past few decades in Pakistan and PaK region. Recent earthquakes of October 2005 in Muzaffarabad and 2019 in Mirpur AJ&K showed the worst picture of construction practices and people risk perception. Due to these earthquakes severe damages were experienced. In order to reduce the damages disaster risk reduction strategies should be implemented. It is necessary to measure the perceived risk as well as physical vulnerability in order to formulate disaster risk reduction techniques.

Risk perception has different meanings to different people. These meanings vary with age, gender, experience of disaster and education etc [3]. Risk perception reveals that how much a community aware is. In absence of detailed physical vulnerability data, perceived risk can be used for suggesting risk reduction policies. Physical vulnerability assessment is another important parameter in disaster risk reduction studies. Lack of implementation of building codes and poor workmanship are increasing the vulnerability of structures [31]. People preparedness against a disaster is of vital importance, as preparedness decreases the level of hazard. In Baluchistan province of Pakistan disaster preparedness plans are prepared on provincial level but there is no practical implementation of them on grass root level. Also community has not taken any initiative to cope up with seismic emergencies [24]. This situation demands a detailed study of perceived and actual risk along with preparedness indicators to help disaster management authorities and urban planners to improve relevant disaster risk reduction policies [32].

2.2 People Risk Perception

2.2.1 Concept

The perception of risk involves process of collection, selection and interpretation of signals about uncertain impacts of activities, events (man made or natural) and technologies. These signals can be from direct observation (for example witnessing a road accident) or through different sources of information (for example reading a report on earthquake risk in a specific area). Perceptions may vary depending upon the nature of risk, context of risk, socio-economic conditions and personality of the individual. Risk perception is defined as subjective judgement by many researchers as it depends upon the subject's mood, attitude and opinion [10]. Risk perception is not the existing situation but the mental picture of risk against a future disaster [33].

Approaches

Risk perception studies is a developing field, different approaches and theories are being used to study risk perception. There are two main approaches used for studying risk perception, the constructivist approach and realist approach [34]. Constructivist approach argues that risk is not objective it is subjective and it is constructed based upon social factors [35]. Realist approach tries to bring perception as close as possible to the objective risk of an activity or an event. To bring perception closer to actual risk, more understanding and information about risk should be provided. Further research resulted in two main models, Psychometric approach and cultural theory approach [30].

Psychometric approach

This type of model was launched in 1978 by Fichoff [30]. Psychometric approach focuses on psychological aspect of human reasoning. The way humans think, observe, draw conclusions and act accordingly. Psychometric approach goes beyond the social context of an individual and focuses on those elements which shared among cultures and social groups [36]. This approach is based on paradigm and uses gender, races, risk communication and demographic studies. It uses questionnaires and factor based procedures to explain risk. Due to qualitative features and mental models/pictures it is severely criticized [8].

Cultural theory approach

This approach is based on different cultural proto-types which acts as a base for individual's construction of their own cognitive categories [36, 37]. Based on cultural theory there exist four type of people, egalitarian, individualistic, hierarchic and fatalistic. These type of people will concerned with different type of hazards.

Egalitarians: Technology and the environment.

Individualistic: Wars and other threats.

Hierarchic: Law and order

Fatalists: None of the above

The social context, economical aspect and formal sense of a person is believed to be governing his or her beliefs. For better understanding of cultural theory the above mentioned social phenomena should be deeply studied. But no such study has been published yet [30].

2.2.2 Previous studies on risk perception

The southwest Indiana Disaster Community Corporation and Sandia National Laboratories (SNL) in New Mexico city had a joint venture in 1999 for developing a disaster management system that will help significantly in reducing the loss of human lives and lower the cost of disaster recovery in a five countries region. They estimated the risk perception and preparedness on community level and then formulated the community preparedness techniques according to the deficiencies. They used community preparedness and involvement, in addition to automated computing systems, technologies, sensors and simulation tools, these all are integrated using virtual issue process. This system is expected to provide the pre-disaster, during disaster and during recovery information to the community in order to improve their risk perception and preparedness. Which will ultimately help in reduction of human and economic losses [38].

Lindel and Prater [39] selected a high seismic hazard zone (Southern California) and moderate seismic hazard zone (Western Washington) to study demographic characteristics, personal hazard experience, hazard intrusiveness (involve deeply), risk perception and tendency towards adaptation of hazard adjustments (i-e steps taken to reduce effects of disasters). Results revealed that about mentioned characteristics change with change in seismicity of the area. Multi variate regression analysis favored the chain hypothesis. In this chain seismicity and demographic characteristics cause hazard experience, hazard experience causes hazard intrusiveness, perceived risk also causes hazard intrusiveness, this hazard intrusiveness results in adoption of hazard adjustments. In this way the true risk perception along with other factors results in adoption of risk reduction measures, which is the ultimate goal [39].

Risk perception and preparedness against flood risk has been measured in alpine valley in the north of Italy. 407 residents from 9 communities were interviewed using structured questionnaire. Perception was assessed by means of a one dimensional scale that has been developed and tested by the other authors. One dimensional scale asked the participants to estimate the likelihood of different flood consequences and express feelings of worry associated with them. Results revealed that most of the residents were on a satisfactory level of preparedness. Regression and correlational analysis showed that disaster preparedness was positively associated with risk perception. The results were confirmed by two of the previous studies. Results were also interpreted while considering socio-demographic factors [40].

Dyer [41] has conducted a study to find relationship between social vulnerability (ability of individual in a household to recover from impacts of a natural hazard) and perceived risk in a exposed vulnerable environment [41]. Prevailing assumption was that social vulnerability influences the level of risk perception in an exposed, vulnerable environment. Research was based on structured questionnaire having 35 items, including socio-economic characteristics, socio-demographic profile, risk perception indicators and the urban context of the subjects. Samples were collected using random sampling techniques form same area but having different social vulnerability (poverty ratio, demographic vulnerability and level of education etc). the results of statistical analysis revealed that there is a significant difference in level of perception of the two samples. The sample collected from high social vulnerable area has high level of risk perception and vice versa. So the increased level of vulnerability urges people to get better understanding of seismic risk. However this study failed to point out the extend to which difference is due to social vulnerability on the two samples and what is role of other factors which were not the part of research like role of media [42].The impact of mass-media was earlier studied by Fritzsche [43].

Risk perception and awareness of risk are the most crucial steps in process of taking precautionary measures at individual level, against various disasters. Factors affecting risk perception and better awareness about earthquakes among residents of Istanbul Turkey were studied using field survey. Two districts of Istanbul were divided into sub-districts based on different seismic risk levels and socio-economic levels. 1123 respondents were interview for this study. The findings showed that respondent's level of knowledge about awareness and risk perception was satisfactory but level of knowledge about mitigation and preparedness needs improvement. Studies indicate that future disaster preparedness and mitigation programs should target the areas with low socio-economic profiles. The seismicity of houses also had a great influence on respondent's risk perception, which indicated that risk perception was nearly the same as that of actual risk. Gender, age, past experience and other factors had also an influence on earthquake knowledge and perception. Unlike Uddin and Engi study, this study focused only on seismic hazards [12].

Washinger et al [36] in 2013 studied selected literature on risk perception, mainly in connection with natural hazards and presented a review. This studies includes numerous case studies on perception and preparedness while dealing with floods, droughts, earthquakes, wild fires and landslides. This study reveals that personal experience and trust in the authorities has more effect on risk perception than the cultural and individual factors like gender, age, education and income etc. General assumption is that higher level of risk perception leads to high personal protective measures. But the results revealed that the opposite may also occur and the individuals with high risk perception still not choose to prepare themselves. This can occur due to distrust in authorities and unwillingness of an individual to invest in protective measures. The solution of this problem is to increase public involvement and participation in awareness and mitigation programs. The limitation of this study is that all the case studies were taken from continent Europe [36].

Pakistan is a country that lies on active seismic region. Quetta being one of the most vulnerable cities of Pakistan has been frequently visited by earthquakes in recent past. This study aimed to examine the perception of people living in Quetta city. Survey was conducted among 200 households using Random sampling techniques, along with this key informants were also interviewed. Community group discussion sessions were also conducted. The results revealed that earthquake risk perception associates significantly with education, income and age. Unlike Washinger et. al [36] who argued that gender , age and education has less effect on risk perception , which personal experience and trust in authorities act as primary components. The study also showed that there is difference between risk perception of different community members, government and non-government officials. The attitude towards future hazards was observed to be fatalistic. The studies suggested that there should be a program creating public awareness and preparedness for risk reduction. This study has not involved the participation of women because of cultural norms. So this study fails to compare the risk perception among the two genders [24].

In the recent past a massive earthquake visited Baluchistan Pakistan in 2013, which resulted in collapse of nearly 90% of buildings in district Awaran. The reason of this heavy damage was low preparedness, old and poorly constructed buildings as well as non-compliance of building codes. Lack of implementation of building codes resulted in increased level of vulnerability, as the area is already at higher seismic risk. This study was intended to access the people's perception and awareness about understanding and implementation of building code of Pakistan, to increase resilience against disaster. Also the role of related government institutes was studied. Quetta city was divided into two zones based on level of seismic risk. Results revealed that out of 200 respondents most of them face earthquake time to time, but still they are marginally aware of seismic risks and building codes. Authorities have not taken bold steps to implement building codes, neither the people itself tried to consider building codes while doing construction. As a result the new construction like the old ones is a stock of vulnerable buildings. Like earlier studies by Ainuddin et al 2014 [24]. The author suggests public awareness and preparedness programs at district level, but he also recommends adoption and strict enforcement of building codes as a primary step towards seismic risk reduction measures. As also confirmed by the previous studies that only those buildings in Quetta were survived during earthquake which were build following building codes suggested by Kumar [44].

Factors that influence an individual to adopt seismic risk mitigation behavior were intended to study. Respondents were surveyed using questionnaire, and then they were divided into two group. First those who have adopted Risk mitigation measures (RMMs) and second those who have not adopted RMMs like building inspection, strengthening of foundation and retrofitting etc. Results showed that those who were adopting RMMs, perceived less loss as compared to those who don't adopt RMMs. But perceived seismic risk was more for those who have adopted RMMs. However presence of more than one children or any other financial constraint may reduce the willingness towards RMMs. But this study has not discussed the conditions of buildings of respondents, reasons of perception of higher loss perception and its association with fatalism [45].

Sichuan province of China has been frequently visited by disruptive earthquakes, one of those is earthquake 2008. This research tries to study earthquake risk perception in most badly damaged area of Sichuan. Three assumptions were tested during the research which includes risk perception as a function of household characteristics of individuals, perception is positively associated with hazard experience and negatively associated with financial preparedness. Results showed that most affected victims (those having disaster experience) tend to rate the risk higher. People who are better prepared for risk, tend to rate the risk lower. Age, gender and occupation also had an effect on risk perception [13].

Perceived risk is also known as social vulnerability, and vulnerability related to building qualification is called as physical vulnerability. These both when studied combined are called as overall vulnerability. Various factors including age, gender, population density, distance from facilities and building information was included in the survey conducted in Fahadan district in Yazd city of Iran. Based on results of social and physical vulnerability, social and physical vulnerability maps were prepared with the help of GIS (Geographical information system). Analysis of social vulnerability map showed that the area with low social vulnerability have high rate of migration, increasing age of people and low level of income. Contrary to Alex and Lewis 2015 [13] studies strong association between socio-economic factors and physical vulnerability was found. Physical vulnerability map revealed that most of the (49%) of the area is highly vulnerable due to use of adobe (sun dried bricks), mud mortar, narrow streets and presence of old textured cultural buildings. Some effective mitigation and preparedness program were suggested in order to improve both the social and physical vulnerabilities, but no relation between social and physical vulnerabilities was studied [46].

817 students were interviewed in the state of Oaxaca, Mexico in order to study their seismic risk perception, preparedness and awareness. Samples were taken both from urban as well as semi-rural areas. Results revealed that 25% of the students perceived the risk higher, 50% perceived moderate and 19% reported low perceived coping ability. Female got lower risk perception and greater as reported earlier by Aliabaadi et al 2015 [46]. Further results revealed that most of the students don’t have enough knowledge and abilities about how to behave during and after earthquake. But as compared to semi-rural areas students of urban areas were well prepared. Studies suggested to include special topics about disaster studies in the curriculum. Although this study is only limited to students but it also showed comparison of vulnerability and preparedness in semi-rural areas and urban areas [20].

Relation and variation between perceived risk and actual risk is necessary to study for successful implementation of preparedness measures. This study considers flood for studying actual and perceived risk in three districts Rawalpindi, Muzaffargarh and Sialkot of Punjab Province Pakistan. Households of these areas were surveyed using well defined indicators. Results revealed that people living in flood prone areas are more vulnerable as compared to those living in other cities. Analysis showed that the level of actual and perceived risk is different in different cities. Actual and perceived risk have a positive correlation in all the three cities. So the perceived risk increases as the actual risk increases. Here perceived risk and actual risk are parallel, so in absence of actual risk data, perceived risk data can be used as an alternative for formulating risk reduction measures [47]. As earlier study revealed that physical condition of the area and house has an impact on risk perception [12].

Khan et al. studied empirical relationship between seismic perception and physical vulnerability in the Malakand district of Pakistan which is a high earthquake risk area. Area was divided into two sub-districts having different seismicity. 400 respondents selected through random sampling were interviewed using semi-structured questionnaires and their residences were surveyed through rapid visual screening technique. Results showed that seismic perception varies along with houses type, past experiences, preparedness and capacities. These results are consistent with Alex and Lewis research [32]. A strong and positive correlation was found between overall risk perception of people and physical vulnerability of their houses. These results were also proved by a previous study by Yesil et al [12].

2.3 Preparedness

The study to determine the preparedness level of 181 elementary and secondary schools in four cities located in South East Anatolia fault zone of Turkey. A disaster preparedness questionnaire consisting of 27 indicators was used for interviewing school directors or administrators. Results showed the actual picture of preparedness level as well as physical condition of schools. This study aims to increase awareness of the school directors in order to reduce the impact of earthquake on buildings as well as the occupants. The limitation of this study is that only school directors were interviewed during the research, it could be improved by observations, further interviews and other qualitative methods [48].

Similar study was conducted in Istanbul Turkey. Schools along with their children were addressed. Istanbul having more than 4 million students and high seismicity demands well prepared students and their buildings. Unsafe and less prepared school children will result in killed, injured, disabled and traumatized children and also schools supplies and equipment will be damaged or disturbed. Results revealed that in schools ‘’ Disaster week’’ is celebrated every year for creating awareness about disasters and some drills are also performed, but in most of the schools this is done just as a ‘’formality’’. The trainers have positive attitude towards disaster education but they don’t have enough knowledge in detail for disaster preparedness education. Studies suggest that earthquake resistant buildings on one hand will create safe platform for uninterrupted studies on the other hand will provide emergency shelters during earthquakes. If the school buildings and students were not considered during disaster risk reduction measures it will result in massive loss of lives and buildings as it happened in 2005 earthquake of Azad Jammu & Kashmir 2005. This earthquake resulted in damage of 1300 school buildings [1].

Miceli et al [40] studied preparedness against floods in Turkey. Four hundred respondents from 9 communities were selected and interviewed using structured questionnaires. Respondents were asked to adopt protective behavior against floods. Overall results showed that most of respondents were fairly prepared to deal a flood disaster in future. This study also concluded that positive correlation occurs between disaster preparedness and risk perception [40].

Baluchistan being one of the most earthquake prone regions of Pakistan, has been frequently visited by earthquakes in past, which resulted in loss of thousands of lives and infrastructure. Ainuddin and Routary [24] studied disaster preparedness and issues associated with it. This is a multi-dimensional study based on field visits, group discussions and interviews of key informants. This study covers the preparedness at community and organizational level. Results showed that disaster impacts are handled by reactive approach at provincial level. No programs and projects about earthquake preparedness and mitigation has been initiated. The community is vulnerable to multiple hazards associated with earthquakes, but still the community itself did not take any initiative to manage disasters. Thus it can be concluded that community and organizations are not well prepared for any future earthquake, this situation increases vulnerability, which leads to loss of lives and infrastructure, as it happened in past earthquakes. It is recommended that national and provincial level disaster management institutions must coordinate with district level authorities before and after disasters. On the other hand community should also mobilize their own resources for initiating disaster management activities. Capacity building at grass root level is necessary for disaster risk reduction at community level [49].

Role of media in creating awareness and increasing preparedness can't be denied. Hong et al [22] aimed to analyze the role of media exposure in changing preparedness behaviors for natural and man-made disasters in Hang Zhou, China using 688 questionnaires. The Johnson-Nyman technique was used to test the conditional effect of media exposure on risk perception and preparedness behaviors. Results indicated that media exposure has positive impact on risk perception and preparedness. Risk perception played a mediating role between media exposure and preparedness. So it is recommended that media programs should provide more comprehensive coverage about risk perception and preparedness. As the social learning theory verifies that individuals don't have to learn through personal experience but they adjust their preparedness behaviors by observing others such as media shows etc.

Researchers have given considerable attention to the physical or material preparedness against disasters. But less attention has been given to study psychological preparedness for a disaster. This study was conducted in Australia, while surveying 1253 households using online survey. Psychological preparedness scale used two domains, first knowledge and management of external situation and second is awareness and anticipation of person's psychological response. Analysis showed that several factors were associated with both psychological and material preparedness including higher mindfulness, previous experience of disaster or threat, previous emergency training and low stress scores etc. it suggests that further studies should be done for better understanding and conceptualization of psychological preparedness [23]. This study also confirms that higher level of psychological preparedness results in high material preparedness as previously studied by Morrissey and Reser [50].

2.4 Physical Vulnerability

Physical vulnerability can be defined as potential of a building to suffer a level of damage when it is subjected to a seismic event of known intensity [51]. Physical vulnerability can also be used to indirectly measure the reduction in structural efficacy of buildings or building's residual ability to guarantee its expected use or function under normal circumstances [52].

Cities subjected to seismic risk contain a large number of vulnerable buildings. Duzce city of Turkey has been visited by two major earthquakes in 1999, resulting in some level of damage. This study was conducted to estimate the physical vulnerability of the building stock. A two level survey procedure was used in which first building was examined externally and in next level it was thoroughly observed by entering into the building. 477 buildings were surveyed and buildings were categorized was none, light (can be used after minor repairs), moderate(requires structural repairs) and severe or collapsed which needs seismic capacity restoration or demolition). Results of street level (Level 1) survey revealed that 24% of the buildings lie in severely damaged or near to collapse category. While in results of level 2 this percentage was increased to 25%. This study considered soil conditions as uniform and topography as flat. Also did not consider short column effect and pounding effect, so for more realistic results these factors must be considered [53].

Historic brick masonry buildings have less lateral resistance, so their physical vulnerability must be tested to formulate a better strengthening technique. This study includes rapid seismic evaluation of historic brick masonry buildings located in the city of Vienna, Austria using

Rapid Visual screening (RVS) technique. The buildings were categorized in four vulnerability classes based on their structural parameters and damage relevance. Structural parameters (SP) includes geometry of building, horizontal and vertical irregularities, state of preservation, quality of material, type of foundation and foundation soil, while damage relevance (DR) factors includes human and economic damage, no of exposed persons and importance of the object for public. This derived classification was used to prepare earthquake induced damage scenarios, for Viennese areas with a huge stock of historic masonry buildings. 375 such buildings were evaluated and their results were integrated into a local vulnerability map. This map can provide useful information for rescue and safety measures. This study provides a basis for detailed investigation of objects identified to be potentially vulnerable against seismic activity. Unlike Sucuoglu's [53] study this was only limited to brick masonry buildings only [54].

Estimation of physical vulnerability of old masonry residential units is as important as that of old historic cultural buildings. This study considered 500 buildings of both types in the old city centre of Sexial , Portugal. The methodology is based on estimating Vulnerability index(VI), evaluation of loss index and loss scenarios. The data base regarding vulnerability, damage and loss scenarios, building characteristics and conservation states was managed and results were analyzed using ArcGis 9.3 software which is an application of Geographical information system (GIS). GIS helps to acquire a global view of the area under study for increasing effectiveness of rehabilitation strategies and risk mitigation measures. Results revealed that even the area under the consideration moderate seismic hazard but due to high vulnerability the damage associated is highly vulnerable. The results of this study can be used for formulation of retrofitting techniques which can reduce the vulnerability and damage. Author suggest details studies of parameters used for measuring vulnerability and uncertainties associated with them [55].

Physical vulnerability of buildings due to potential hazard of landslides was evaluated by Silva and Pereira [19]. Each building was surveyed using semi quantitative survey form which includes all indicators such as slope angle, aspect and curvature, inverse wetness angle and lithology etc. the results of this study supported the arguments of previous studies that potential loss is associated with physical vulnerability of the buildings and their economic value [19].
The stability of buildings in regions prone to earthquakes depends upon the structural behavior of those buildings subjects to ground motions. Chennai is thirty fourth largest city of the world

and is being prone to moderate earthquakes in past. Due to its high building density, high population and moderate seismic risk a small area (ward) from this city was considered for physical vulnerability evaluation. Aerial photographs were used for assessing different vertical and horizontal irregularities present in buildings. The results of parameters obtained from aerial photographs were validated by physical verification of sample buildings. The aerial photographs data, area features, land and road features and its surroundings were digitized and incorporated in GIS platform to create digital vector map. The vulnerability map obtained from vulnerability data and hazard map were superimposed on the digital vector image of the area. Thus the map shows the buildings with require minor repairs and also those who require retrofitting techniques. Despite of being at moderate seismic risk, almost 30% of the buildings are in near to collapse category. This depicts serious potential loss which can be reduced if the authorities use these maps to identify those buildings which require retrofitting. The limitation of this study is that it considered only five stories or above buildings [15].

In cities prone to seismic events, old buildings are soft target of earthquakes. Yazd being an old city of Iran, has maintained its old heritage and physical conditions, but it is not safe enough against earthquakes. This study considers evaluation of physical as well as social vulnerability of the city. The analysis is based on AHP method which consists of three steps. First step is creation of binary comparison matrices, these comparison matrices were filled by thirty five academic related disaster management experts according to their own knowledge. In second step weight of different steps is calculated and in third step consistency ratio (CR) is calculated which is an indicator that either the results obtained are free from errors and consistent. Two different maps of physical and social vulnerability were prepared and by superimposing there two overall vulnerability map was prepared using GIS. Map shows that 49% of the city lies in highly vulnerable class. This study suggests that international research and funding should be done for cultural heritage risk reduction. Also development of social and physical indicators and civic participation in this process will result in better use of cultural and residential places in this district [46].

Older buildings in Australia are vulnerable to earthquake as they are constructed before implementation of seismic codes, that’s why despite of being in moderate seismicity, seismic risk is higher. This study considers unreinforced masonry buildings (URM) and Timber buildings. Vulnerability of URM and timber structures constructed before 1945 were compared with those after 1945 were compared. GEM empirical vulnerability assessment methodology was used to assess physical vulnerability which includes four steps. Firstly a loss database is prepared, then optimum vulnerability functions are defined, and fitted to the loss data, in third step its goodness of fit is assessed and finally for the best-fitted model, 90% prediction intervals are constructed by bootstrap analysis. The results showed that unreinforced masonry structures constructed before 1945 are most vulnerable and URM constructed after 1945 are next most vulnerable. Timber structures being least vulnerable with no considerable difference between vulnerabilities before and after 1945. The vulnerability functions used here can be used to identify retrofitting strategies to reduce the existing earthquake risk [16].

A field survey was conducted to evaluate physical vulnerability of buildings in Denizli, a mid-sized city of Turkey. Horizontal and vertical irregularities, structural parameters, building types and type of material etc was considered in this survey. Results of physical vulnerability were used for risk and loss assessment against two scenario earthquakes of M6.3 and M7.0. Shelter needs and casualty needs during these earthquakes were estimated. Results revealed that buildings with six or more stories were the most vulnerable, buildings constructed pre-1975 are next vulnerable and buildings with 3-5 stories are least vulnerable. These studies can be further extended in other cities for estimating vulnerability of buildings and losses [56].

Physical vulnerability of 396 buildings damaged by Manipur India earthquake of 2016 was assessed using field survey and then statistical regression analysis. 10 parameters were considered during field survey, but regression analysis revealed that soil type, maintenance condition, apparent construction quality and no of stories were highly significant parameters in analyzing the vulnerability. The author claims that this study can be used as a preliminary assessment technique for identification of physically vulnerable buildings for any sort of disaster risk reduction program [18].

Lifeline buildings must survive and perform uninterruptedly during a disaster. To check the seismic vulnerability of lifeline buildings like fire and emergency services, police, school, hospitals and local administration buildings in the Uttrakhand province of India, Rapid visual screening technique was used. Buildings were classified into five grades based on their expected seismic performance. The grade one represents no damage, grade two represents slight non-structural damage, grade three shows buildings with slight non-structural damage, grade four depicts considerable structural damage and grade five represents collapse. Results revealed that 72% of the surveyed local administration buildings, 64 % schools, 62% police stations, 56% firefighting buildings and 52% hospitals will be collapsed. This will create a challenging situation for search, rescue and emergency service providers as the remaining facilities will be overburdened. Studies revealed that lack of maintenance, poor quality of construction and lack of compliance of safety standards are the main reasons of increased vulnerability. This study recommends prompt demolition and reconstruction of all grade 5 buildings, along with rehabilitation and retrofitting of grade 3 and 4 buildings. So the results of this study are also useful in taking disaster risk reduction measures [17].

Studies assessing physical vulnerability and perceived risk recommends authorities to exercise risk reduction measures based on these studies. Risk perception and physical vulnerability for earthquakes have been studied separately but they were not studied in connotation with each other in hazard prone communities of Pakistan. This study aims to find the linkage between perceived risk and the physical vulnerability. District Malakand of KPK province, Pakistan which has been declared as high seismic zone by NDMA is selected as study area. 400 samples from its two sub-districts were obtained using random sampling techniques. Data of perceived risk was collected using face to face interviews of respondents and physical vulnerability form was filled using visual inspection of their residence. Statistical analysis revealed that there occurs a significant positive correlation between overall risk perception and physical vulnerability. Which shows that as the physical vulnerability increases risk perception also increases, but not vice versa. This positive correlation also shows that people might take precautionary measures as their perceived risk increases. Studies also revealed that people have fatalistic attitude towards earthquakes and many other misconceptions are there like, thinking that earthquakes are results of sins. Further no risk reduction programs by relevant authorities were initiated and no initiative was taken by public itself. This study suggests a risk awareness and mitigation program having active public involvement to improve public risk perception and reduce physical vulnerability of their houses. Although this study was very comprehensive attempt in Pakistan, but there were some parameters which were not used in physical vulnerability assessment. Another limitation of this study is that due to cultural restrictions only male respondents were selected for the interview.

2.5 Contribution to the Research

Azad Jammu & Kashmir (AJ&K) lies in Himalayan region, which has frequently been visited by earthquakes in recent past, out of which one major earthquake is Mw 7.6 Kashmir 2005 [26]. Also the building stock in Azad Jammu & Kashmir (AJ&K) has high seismic vulnerability, which has been verified in Mw 7.6 Kashmir 2005 earthquake [27]. According to available information no studies on actual vs perceived risk has been conducted in whole Azad Jammu & Kashmir (AJ&K). So this study will be a great contribution in field of risk studies in Azad Jammu & Kashmir (AJ&K). The methodology used in this study can be used in any earthquake prone area. No of parameters for physical vulnerability and perceived risk evaluation are increased. Indicators of perceived risk and physical vulnerability are further divided into different classes in order to study impact of different indicators on vulnerability and perceived risk. This study involved participation of both male and female, so effect of gender on risk perception will also be know.

3 METHODOLOGY

In this chapter methodology adopted for assessment of association between perceived risk and physical vulnerability is explained along with evaluation of preparedness.

3.1 Profile of the Study Area

3.1.1 Introduction of the study area

Poonch is one of the three divisions of Azad Jammu & Kashmir (AJ&K), four districts Sudhnoti, Bagh, Haveli and Poonch. District Poonch is further divided into four tehsils, one of which is Rawalakot. Tehsil Rawalakot, of district Poonch is a saucer-shaped valley located at an altitude of 1615 meter above the sea level. It has a covered area of 855 square kilometers.

It has a Latitude of 33.5112N and Longitude of 73.4505E. It is linked with Muzaffarabad via Kohala and Rawalpindi Islamabad by neighboring localities of Azad Pattan and Dhalkot etc. The area under study is tehsil Rawalakot, which comprises of rural area, peri urban area and urban area. Rawalakot is a hilly area with a low lying valley, which covers its urban area. Peri-urban areas are mostly located in semi-hilly regions while rural areas are mostly hilly (Figure). It has few streams, most notable of them is Kehan-nullah.

This region features a subtropical highland climate due to high altitude as classified by Koppen climate classification system. Climate varies along with altitude, low lying valley has hot summer and cold winter while high altitude regions have moderate summer and highly cold winter with temperature below -5°C. According to census of 2017, the population of Tehsil Rawalakot is 221706, with an urban population of 56,061. This region has a literacy rate of 81% which is more than the overall literacy rate of PaK region , i-e 77% [57].

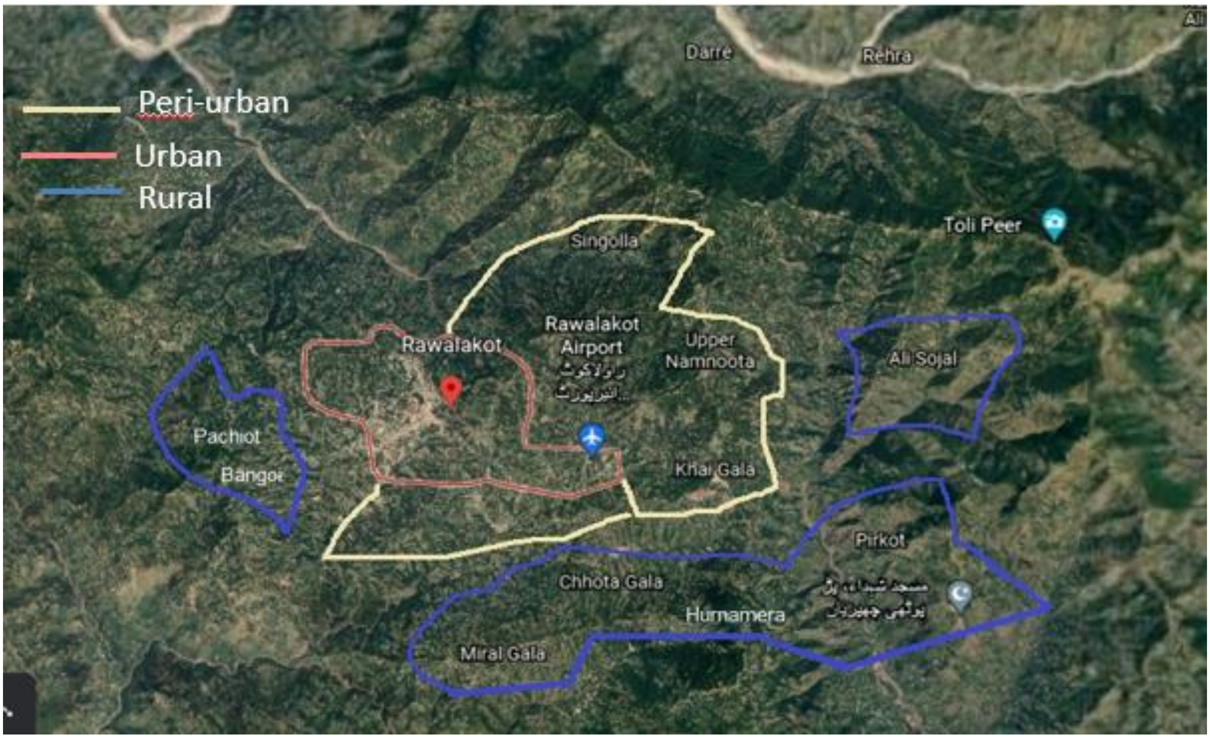

Figure 3.1 Google map showing urban, peri-urban and rural study areas

3.1.2 Risk associated with earthquake

Azad Jammu & Kashmir (AJ&K) lies on Himalayan region, which has been targeted by major earthquakes, one of them is the October 2005 earthquake in AJ&K [5]. The building stock in Azad Jammu & Kashmir (AJ&K) is highly vulnerable to seismic events as it was experienced in October, 2005 earthquake [26].

The October 8th, 2005 earthquake affected almost all aspects of socio-economic life of the people along with the physical infrastructures both in private and public sectors. The loss of human life in Poonch district was 1120 whereas 1883 persons were injured. A total of Rs 873.115 million has been paid as compensation for death and injury cases in Poonch district (up till March, 2007). This includes Rs 746.815 million for the injured, Rs 111.4 million for single death cases in a family and Rs. 13.9 million for multiple death cases. The seismic hazard map of Pakistan showing Rawalakot is given in figure 1.

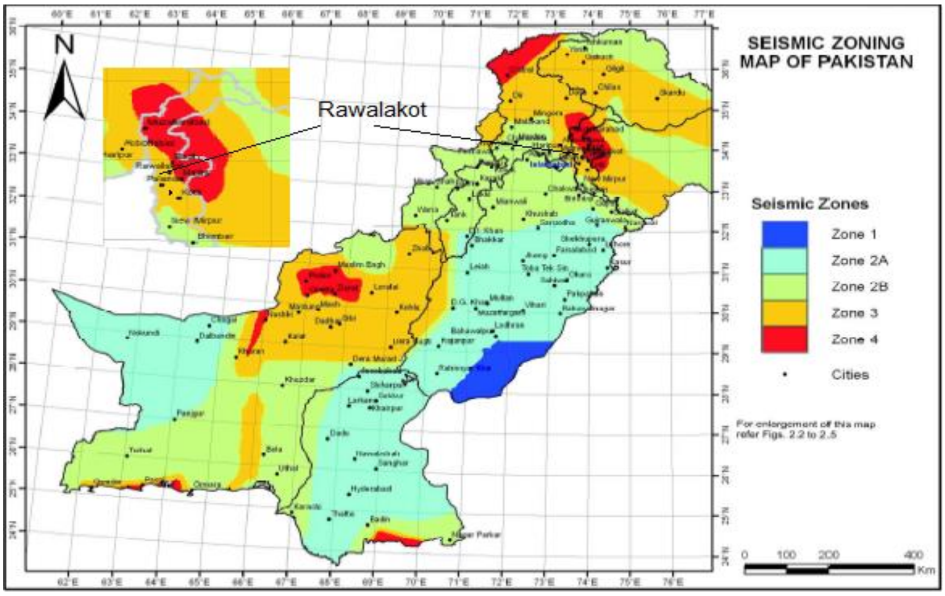

Figure 3.2 Seismic zonation map of Pakistan showing the study area [58]

The district has suffered a significant loss due to the Oct 2005 earthquake. The 83% of the private houses were fully damaged while 15% were partially damaged. The damage to education sector was 95% as 923 schools were damaged in both public and private sector. In health sector, 213 health facilities were fully or partially damaged. There were Rs 8492.3 million direct and Rs 4217.6 million indirect losses in the agriculture sector. In the Environment and Forest sector there were 20 offices and buildings which were damaged due to earthquake. The road infrastructure, 45.4 km metaled and 507 kilometers of link roads with 4 bridges of 311 meter were damaged.

As per ERRA reports in Poonch district, private housing sector suffered a great loss to the extent that 83% (39190) housing structures were totally destroyed whereas 15% (7209) were partially damaged. The remaining 2% were with negligible damages and thus in a livable condition. As compared to Bagh and Muzaffarabad, Poonch district got relatively lesser damages in private housing because of being located at greater distance from epicenter. However, some parts of the district relatively got more damaged than the rest. The cause was both the comparative nearness to the fault line as well as structural design weaknesses in those areas. Again the slope constructions were shocked heavily than the plain area housing units. For example, union councils Ali Sojal, Dhamini, Pakhar and Serrarai suffered greater losses than the rest area on these accounts. So all of these parameters including slope and structural design parameters are included in physical vulnerability studies [57].

The summary of these losses occurred in the whole district Poonch is given below in Table 1.1.

Table 3.1 Losses occurred due to Muzaffarabad earthquake 2005 in district Poonch

S.No	Department	Damages in earthquake 2005 (Facilities)	Loss in Millions
1	Private housing	83% full(39190) 15% partial(7902)	9000m
2	Health facilities	213 health facilities fully or partially damaged	1080m
3	Educational institutions	923 schools (95%)	4615m
4	Road Infrastructures	45.4 km Metaled 507 km Link roads 3 Bridges	2255m
5	Forest & environment offices	20	35m
6	Agriculture	Crops, Agricultural lands	8492.3m Direct 4217.6m Indirect
7	Human losses	1120	125.3m compensation
8	Injuries	1883	746.815m compensation

3.1.3 Seismicity of the study area

Pakistan lies in a high seismic region with two tectonic plates, the Indian plate which is sub ducting underneath Eurasian plate, resulting in multiple thrust faults. These faults are major cause of earthquakes in the region. Significant earthquakes have occurred in the thrust zones are 1555 earthquake of Srinagar Mw =6.7, Shilong earthquake of Mw= 8 and Kashmir earthquake of Mw= 7.6. These seismic activities depict the potential of the region to produce earthquakes. It is said that only a small percentage of energy has been released by the Kashmir earthquake and there is a possibility of more earthquakes even greater than Mw 8 magnitude. Tehsil Rawalakot lies in Zone 3 according to seismic provisions of Building code of Pakistan

2007. Zone 3 has peak horizontal ground acceleration of 0.24-0.32g. NDMA has also declared Rawalakot a high earthquake risk area [27].

3.1.4 Sample size and sampling technique

According to census of 2017, the population of district Poonch is 5,60,571. Tehsil Rawalakot of District Poonch has population of 2,21,706. The population of Rawalakot city comprises of 56,061 persons. Sample size was decided using famous method of sample size calculation known as Taro Yamane method. The Taro Yamane method for sample size calculation was formulated in 1967 by statistician Tare Yamane. It is mathematically illustrated as:

$$n = \frac{\boldsymbol{N}}{(\boldsymbol{1}+\boldsymbol{N}\boldsymbol{e}^{\boldsymbol{2}})}$$

n = Sample size

N= population under study

e = Margin error (its value may be 0.10, 0.05 or 0.01).

For city /Urban area under study N= 56,061 and e is considered = 0.075

So n becomes 177.

But for more accuracy 200 samples (n=200) were collected from Urban area. Peri-urban area under study consists of peri-ubran regions of Singola and Pakkar union councils having population of 44524. Considering e= 0.10, sample size becomes 100. So n= 100 for peri-urban region.

Rural area under study comprises of Banakha, Pachiot Gharbi and Hurnamaira, having a total population of 42507, while is approximately same as that of peri-urban region. So sample size was kept 100 for rural area too**.**

Table 3.2 Estimation of sample size using Yamane's method

Region	Margin error 'e'	Population 'N'	Sample size 'n'
Urban	0.075	56,061	200
Peri-urban	0.10	44524	100
Rural	0.10	42507	100

Primary data collection was done using semi-structured questionnaire. Most of the questions had pre-defined answers, but few of them were not planned in advance. These questionnaires were filled during face to face interviews. A pilot study was conducted using 15 samples. It was helpful in streamlining the questionnaire. Questionnaire has two parts, first of which was used for accessing risk perception of the respondent using interviews and second part was about physical vulnerability evaluation of resident's house. Annex one of it was also translated into national language Urdu, for better understanding but during interview it was observed that a considerable number of respondents had misconceptions about questions. For this reason all of the respondents were asked questions according to ease of their language (English, Urdu or native language Pahari) and forms were filled by the interviewer. Before starting the interview each respondent was briefed about the research to develop his understanding and interest. That's why the response rate was 96%, as only 15 persons out of 415 refused to respond. Both male and female participants in all the three regions participated. The survey was conducted in period of one year, the delay was occurred due to Covid-19 pandemic.

This study uses Index-based methodology for accessing perceived risk and physical vulnerability. Mean and standard deviation methods were used to find the level (high, moderate or low) of perceived risk and physical vulnerability. Sampled paired t-test which compares the means of two measurements taken from the same source, was used to compare the actual risk and perceived risk. To check the influence of physical vulnerability (independent variable) on perceived risk (dependent variable), simple linear regression was used.

3.2 Development of Indices

3.1.1 Seismic iisk perception index

Seismic risk perception involves the evaluation of risk perceived by people. Risk perception index (RPI) was calculated based on twenty indicators selected from pervious literature on risk perception.(Table 1). These twenty indicators are further divided into four dimensions including risk perception due to fear, awareness, trust or attitude. So risk perception indices calculated were Overall risk perception index (ORPI), Fear risk perception index (FRPI), Awareness risk perception index (Aw.RPI) and risk perception index due to attitude (A. RPI). These indicators are shown in Table 3.3. For assigning values to these indicators Likert scale technique was used. This technique is used to rank people's opinions and judgements from low to high or from poor to good. This scale assumes that the distance between each option/choice is equal. All the indicators were assigned values between 1 and 0. Risk perception index of every respondent was calculated by taking average of values of each indicator. Since all the indicators have values between 1 and 0, so mean RPI for each respondent lies between 1 and 0.

Table 3. 3 Risk perception indicators.

Sr. No	Indicators	Categories	Weights	Reasoning	Evidence
		1. Fear			
1.	**Level of the expected earthquake** What is the level of an expected earthquake?	High Moderate Low	1 0.66 0.33	Those who will expect high earthquakes will perceive the risk as greater.	[21,33,55,56]
2.	**Level of afraidness:** How much are you afraid of earthquakes?	High Moderate Low	1 0.66 0.33	Households afraid of earthquakes will perceive more risk.	[56,21]
3.	**Extend of damage in future:** Do you believe that future earthquakes will cause loss of lives and assets?	High Moderate Low	1 0.66 0.33	Those who think that earthquakes will take lives will have more perceived risk.	[35,21,33]
4.	**Possibility of Supply chain breakdown:** Do you think there will break down of supplies after an earthquake?	Yes No	1 0	Those who think the supply chain will break down will perceive high risk.	[57,58,50]
5.	**Thinking about the earthquake:** How frequently you think about seismic events?	Often Seldom Never	1 0.66 0.33	Those who think frequently will perceive more risk.	[56,21]
6.	**Pre earthquake 2005 structure?** A structure constructed before earthquake 2005?	Yes No	1 0	Those who have a pre earthquake structure will feel more fear.	[35]
7.	**Faced earthquake in the past?** Have any earthquake experience?	Yes No	1 0	Those having earthquake experience will perceive more fear.	[33]
		2 Awareness			
8.	**Seismicity of the region:** Do you know you live in a high seismic region?	Yes No	1 0	Those who understand the true seismicity of the area will perceive high risk.	[12]

9.	**House capability to withstand earthquakes:** Do you think your house has the ability to withstand future earthquakes?	No Yes	1 0	Those who think their building is unable to withstand will perceive high risk.	[35,58,33]
10.	**Knowledge about emergency plans:** Do you know about emergency plans and protocols?	Yes No	1 0	Those who know about emergency plans and protocols may perceive high risk.	[35,36]
11.	**Precautionary measures:** Do you have information about precautionary measures?	Yes No	1 0	Those who have knowledge of precautionary measures will perceive high risk.	[35,50]
12.	**First aid training:** Do you have attended First aid training ever?	Yes No	1 0	Those who will have got trained will perceive high risk.	[35]
		3. **Trust**			
13.	**Trust in authorities:** Do you have trust in disaster management authorities & their policies?	Yes No	1 0	Those who don't trust authorities will perceive lower risk.	[33,38]
14.	**Trust in media:** Do you have trust in information sources like digital & print media?	Yes No	1 0	Those who will have no trust will be less informed and will perceive low risk.	[35,33]
15.	**Trust in strategies:** Do you believe in emergency plans & strategies?	Yes No	1 0	Those who believe in emergency plans may perceive higher risk.	[33]
		4. **Attitude / Behavior**			
16.	**Credibility of building code:** Do you think that following building codes will help in reducing risk?	Yes No	1 0	Those who perceive risk will follow building codes to reduce risk.	[35,21,60]
17.	**Trend towards migration:** In case of any threat, are you willing to follow evacuation/ migration orders by authorities?	Yes No	1 0	Households perceiving risk will follow such orders to save themselves.	[33]
18.	**Earthquake effects:**	Yes No	1 0	Those who perceive risk understand that risk can be reduced.	[21,12]

	Do you believe that earthquake effects can be minimized?				
19..	**Effect of natural hazards:** Do you believe that natural hazards are fatalistic? Or can it be avoided?	Can be avoided Fatalistic	1 0	Low-risk perception is associated with fatalism.	[21]
20.	**Allowability of conventional construction**: Do you think conventional construction should be allowed in the high seismic risk zone?	No Yes	1 0	Those who perceive low risk will be willing for conventional construction in seismic regions.	[21]

Risk perception was calculated by using following equation:

$$RPI = \frac{(\sum \boldsymbol{W1+W2+W3}.................\boldsymbol{W20})}{\boldsymbol{n}}$$

Where W stands for weight or value of indicator.

n stands for total no of indicators

based on the twenty indicators shown in table (3.3) overall risk perception index (ORPI) of a respondent from urban area is calculated as below,

The values of these indicators are taken from a data collection form of a respondent form rural area.

$$ORPI = \frac{(\mathbf{1+0.75+0.75+0.75+0+1+0+1+1+1+1+0+1+1+1+1+0+1+1+0})}{\mathbf{20}}$$

So overall risk perception index of the respondent is = 0.7125

Risk perception can be classified into dimensions including fear, awareness, trust and attitude. Indices of each dimension were also calculated in the same way by taking mean the indicators of each dimension.

Fear risk perception index (FRPI) was calculated using equation 3.

$$FRPI = \frac{(\sum \boldsymbol{W1+W2+W3}.................\boldsymbol{W20})}{\boldsymbol{n}} \quad (3)$$

Awareness risk perception index (ARPI) was calculated using equation 4.

$$ARPI = \frac{(\sum \boldsymbol{W1+W2+W3}.................\boldsymbol{W20})}{\boldsymbol{n}} \quad (4)$$

$$ARPI = \frac{(\mathbf{1+0.75+1+1+0+1+0+1+0+1+1+0+1+0+1+1+0+1+1+0})}{\mathbf{20}}$$

Trust risk perception index (TRPI) was calculated using equation 5.

$$TRPI = \frac{(\sum W1 + W2 + W3 \ldots\ldots\ldots\ldots W20)}{n} \quad (5)$$

$$TRPI = \frac{(1+0.50+0.75+1+0+1+0+1+1+0+1+0+1+1+1+1+0+1+1+0)}{20}$$

Attitude risk perception index (At.RPI) was calculated using equation 6.

$$At.\ RPI = \frac{(\sum W1 + W2 + W3 \ldots\ldots\ldots\ldots Wn)}{n} \quad (6)$$

The values of these indicators are taken from a data collection form of a respondent form rural area.

$$At.\ RPI = \frac{(1+0+1+1)}{4}$$

Attitude RPI = 0.75

3.1.2 Preparedness index

Earthquake preparedness includes the protective measures adopted to reduce the adverse effect of earthquake. Preparedness was quantified by evaluating preparedness index for each household. Indicators for both psychological and physical (material) preparedness were included in survey form, as shown in Table 3.4

Table 3.4 Earthquake preparedness Indicators

S No	Indicator	Options	Weightage	Evidence from research
1.	Do you have mentally prepared yourself for situations that might be difficult or stressful?	Yes No	1 0	[59,12]
2.	Do you have the ability to calm down yourself and others too in earthquake-like situations?	Yes No	1 0	[59,12]
3.	Do you have emergency contact numbers on your phone?	Yes No	1 0	[59,62]
4.	Will you be able to monitor the news bulletin during disastrous situations regularly?	Yes No	1 0	[59,62,46]
5.	Do you have a structural design of your structure before construction?	Yes No	1 0	[35]
6.	Do you have secured/anchored high furniture which may fall during an earthquake?	Yes No	1 0	[35]
7.	Do you have retrofitted your building?	Yes No	1 0	[35,50]
8.	Do you have secured loose non-structural parts of your building?	Yes No	1 0	[64]
9.	Do you carry out maintenance of your house regularly?	Yes No	1 0	[27]
10.	Do you have an alternate house in a non-seismic / safer zone?	Yes No	1 0	[45]

11.	Do you have purchased insurance against natural disasters?	Yes No	1 0	[50,37]
12.	Do you or your family have alternative sources of income that are unlikely to be affected by strong earthquakes?	Yes No	1 0	[37]
13.	Do you or your family own any form of an asset other than your house?	Yes No	1 0	[37]
14.	Are you able to get loans from banks to get your houses rebuilt in case of any destruction?	Yes No	1 0	[37,33]
15.	Would your family members/ relatives will financially support you in rebuilding your house if it gets damaged?	Yes No	1 0	[37,33]
16.	Do you have a first aid kit at your home?	Yes No	1 0	[50]
17.	Do you have a fire extinguisher at your home?	Yes No	1 0	[50]
18.	Do you have taken earthquake training drills?	Yes No	1 0	[50]

3.1.3 Physical vulnerability index

Physical vulnerability defines the structural inadequacy of a building against earthquakes. Index based approach was used to calculate physical vulnerability of the residential units. 28 indicators were used to evaluate physical vulnerability. Physical vulnerability indicators were broadly classified into ten dimensions including soil and site data, building material data, type of construction, building age and condition, vertical irregularities, plan irregularities, poun0ding effect, redundancy, torsional effects and vulnerability due to non-structural parts (Table 3.5). All the factors were assigned values between 0 and 1. Physical vulnerability index was evaluated by taking average of all the indicators.

Physical vulnerability index can be calculated by following equation:

$$PVI = \frac{(\sum W1+W2+W3 \ldots\ldots\ldots\ldots W28)}{n}$$

$$PVI = \frac{(1+0.75+0.66+0.33+1+.75+01+0.33+.50+0.50+0+0+1+1+1+1+0+1+1+1+0.5+1+0.5+1+0+1+0+1)}{20}$$

PVI = 0.941

So physical vulnerability index for a particular residential unit in 0.941.

Table 3.5 Physical vulnerability indicators

S.No	Indicators	Categories	Weights	Reasoning	Evidence from research
a) Soil & Site data					
1.	Ground terrain	Slope Non slope	1 0	Sloppy terrains have high vulnerability	[1,2,7]
2.	Soil type	Soft soils Stiff soil Dense soil & hard rock Hard rock	1 0.75 0.50 0.25	Loose and weak soils amplify earthquake forces.	[2,3,4,6,7]
b) Building material data					
3.	Material quality	Poor Average Excellent	1 0.66 0.33	Buildings with poor construction materials are more vulnerable.	[6,1]
4.	Masonry material	Stone Hollow blocks Bricks	1 0.66 0.33	Heavy mass and poor interlocking of stone masonry makes it more vulnerable.	[10]
c) Type of construction					
5.	Type of structure	Unconfined masonry Confined masonry RC frame with infill walls Confined masonry with corrugated sheet roof	1 0.75 0.50 0.25	Confined, reinforced and light weight structures are less vulnerable.	[2,4]
6.	Building design & supervision	Intuitive based design by client Local contractor Professional/Govt. authorities.	1 0.75 0.50	Properly designed structures are more ductile so less vulnerable.	[6]
7.	Height & No of stories	Greater than 3 3 2 1	1 0.75 0.50 0.25	Along the height vulnerability also increases	[1,2,3,4,6,7,9]

8.	Apparent construction quality	Poor Moderate Excellent	1 0.66 0.33	Poor material gives less strong & more vulnerable buildings	[6,1]
d). Building age & condition					
9.	Building age (years)	Above 30 21-30 11-20 Less than 10	1 0.75 0.50 0.35	Along the age strength decreases thus vulnerability increases	[4,9,10,11]
10.	Cracking	Structural Non structural No cracking	1 0.50 0	Cracked buildings are weak and more vulnerable	[1,2,6]
11.	Maintenance of building	Not done Done	1 0	Less maintained buildings are more vulnerable	[3,7]
e) Vertical Irregularities					
12.	Short columns	Present Absent	1 0	Short column effect may lead to high shear concentration, thus increases vulnerability	[4,1,5,8]
13.	Floating & Hanging columns	Yes No	1 0	They have discontinuous load (Vertical & seismic) transfer pattern.	[2,3,6,8]
14.	Soft story (Due to masonry infills)	Yes No	1 0	Soft story effect leads to increased displacement thus more vulnerability	[3,6,7,8]
15.	Soft story (Due to relatively taller columns)	Yes No	1 0	Soft story effect leads to increased displacement thus more vulnerability	[3,6,7,14]
16.	Alterations (Adding stories /increasing floors)	Yes No	1 0	It may over load the building or disturb load transfer pattern	[13]

17.	Heavy mass at top (water tank etc)	Yes No	1 0	Heavy mass at top attracts more seismic forces thus increases vulnerability	[7]
18.	Out of plane set back	Yes No	1 0	Sudden change in stiffness increases vulnerability of a structure	[14]
f) Plan Irregularities					
19.	Plan configuration	Irregular Regular	1 0	Irregular shapes cause sudden change in shape & strength so more vulnerable	[2,5,6,7,8,9]
20.	Substantial Overhangs greater than 1.5m)	Yes No	1 0	Over hangs attract over turning moment thus increase vulnerability	[6,3,9,7,10]
21.	Re-entrant corners	Exist Don't exist	1 0	Irregularities in plan increase vulnerability	[2,5,6,7,14]
22.	Diaphragm opening	Opening wide more than 50% of diaphragm width Less than 50% No opening	1 0.50 0	Irregularity in diaphragm makes structure more vulnerable	[14]
g) Pounding effect					
23.	Distance b/w adjacent buildings	Distance less than 4% of small building's height Distance less than 4% of small building's height	1 0	Adjacent buildings may collide during seismic event thus increased vulnerability	[7,4]
h) Redundancy					
24.	Existence of more than 2 bays.	Yes No	0 1	More redundant the structures less vulnerable they are.	[14]

i) Torsional effects					
25.	Location of masonry infills	Irregular Regular	1 0	Changing stiffness on different faces of structure make structure more vulnerable.	[14]
j) Non-structural parts					
26.	Parapets anchorage	Not anchored Anchored	1 0	Unanchored parapets may over turn and fall down thus are more vulnerable	[7,6,11]
27.	Inadequately supported Sun shades or canopies	Yes No	1 0	Unsupported sun shades increases more vulnerability	[14]
28.	Heavy cladding	Yes No	1 0	Heavy appendages and claddings may fall down causing casualties.	[14]

4. RESULTS AND DISCUSSIONS

4.1 Socio-economic Indicators

Both male and female participants actively took part in interviews. Around 17 percent of the total participants were female, with most participation of women was from urban areas. All respondents were Pahari (native language) speakers. The average age of respondents in urban, peri-urban, and rural areas was 37, 39, and 35 years respectively. The average household size was almost six in all the three study areas. The most dominant occupation was trade and business in urban and peri-urban regions, while it is government job in the rural area. The urban area had a better economic status with an average monthly income of 81100 PKR, while it was 77845 PKR and 80690 PKR for peri-urban and rural areas respectively. The urban area also had a better educational status with the least percentage of illiterate people i-e 4%, while the other two areas have 6% of illiterate people. People with university or graduation level education were most in the urban area. 64% of the respondents had no patient at home, while 33% had no children at home. The summary of descriptive statistics is shown in Table 4.1

Table 4.1 Socioeconomic profile of the respondents

Socioeconomic Characteristics	Weights	Urban Freq.	Urban %	Peri urban Freq.	Peri urban %	Rural Freq.	Rural %	Chi square test
Age	<25 26-30 31-46 46-60 >60	53 30 73 29 15	26.5 15 36.5 14.5 7.5	20 15 33 21 11	20 15 33 21 11	28 16 37 14 5	28 16 37 14 5	[1]$\chi 2=224.96$ [2]df=61 [3]p=0.000
Mean Standard dev.		37.165 23.121		39.47 15.84		35.23 13.36		
Monthly income	≤35000 36000-60000 >60000	55 60 85	27.5 30 42.5	40 25 35	40 25 35	47 27 26	47 27 26	$\chi 2=442.7$ df=14 p=0.000
Mean Standard dev.		81100 60046		77845 65802		80690 129900		
House ownership	Rented Owned	42 158	21 79	4 96	4 96	2 98	2 98	$\chi 2=605.72$ df=50 p=0.000

[1] $\chi 2$ = Chi square

[2] df = Degree of freedom

[3] P = Significance value

Mean Standard dev.		1.80 0.42		1.96 .020		2.02 0.345		
Household size	<6 7-10 >10	139 49 12	69.5 24.5 6	63 32 5	63 32 5	61 34 5	61 34 5	χ2=835 df=3 p=0.000
Mean Standard dev.		5.75 23.12		5.86 2.375		6.14 2.50		
Educational Profile	Illiterate Primary Middle High/College University	4 38 41 38 79	2 21.5 32.5 20	6 24 31 15 24	6 24 31 15 24	6 23 20 14 37	6 23 20 14 37	χ2=175.76 df=3 p=0.000
Mean Standard dev.		3.27 1.23		3.60 1.31		3.36 1.17		

Out of total number of respondents only 17% were female as shown in Figure 4.1.

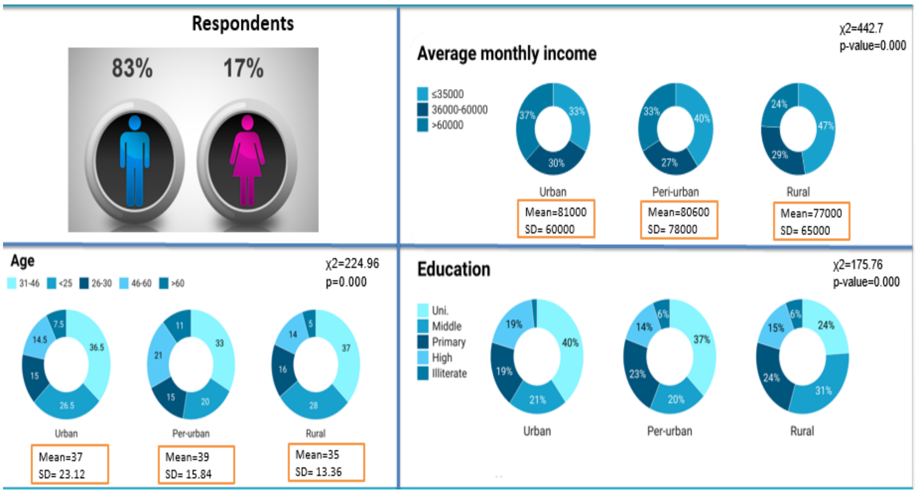

Figure 4.1 Graphical representation of important socio-economic indicators

Graphical representation indicates that 83% of the respondents are male. Respondents with high monthly income are highest in peri-urban and low monthly income are highest in rural area. Average age of all the study areas is almost same. Urban area has the most respondents with university level education.

4.2 Risk Perception Index

Risk perception assessment is an important constituent in the formulation of disaster risk reduction measures. Most of the variation in seismic risk perception was observed due to fear of future earthquakes, expected losses, breakdown of supplies, and damage to the residence. 44% of respondents from an urban area, 51% from the peri-urban area, and 49% from rural areas believed that earthquakes occur due to our sins and religious disobedience, despite of living in an earthquake-prone region.

Most of the respondents (67%) believed that the effects of earthquakes could be minimized by adopting precautionary measures, while others (33%) had a fatalistic attitude towards earthquakes. Fatalistic persons believe in destiny and think that whatever is meant to happen will happen, and no use of resources or safety measures can stop it. Fatalistic attitude stops people from taking preparedness measures, and thus it results in increased vulnerability, as confirmed by an earlier study [21].

32% of the respondents believed that their houses would not withstand any future earthquake. 44% believed that in case of a massive earthquake, interruption of supplies would occur, as most of the goods are supplied from Punjab, Pakistan via Azad Pattan Bridge, which may collapse during an earthquake. Chi-square test of independence revealed that respondents with earthquake experience had greater risk perception, but they also were failed to adopt precautionary measures mainly due to fatalistic attitude and economic restrictions.

The highest risk perception index found in urban, peri-urban, and rural areas was 0.95, 0.86, and 0.90, respectively. Analysis of overall risk perception revealed that most of the respondents with higher risk perception were in a rural area (22%). Only 20% of the overall respondents had a higher risk perception level. Almost half (52%) of the population was found to have moderate to high-risk perception (Table 4.2).

Despite a past devastating earthquake of October 2005 and being declared as a high seismic risk area, still, 27% of people believe that the area is not an earthquake-prone region, this depicts the weak knowledge about the disasters. 45% of respondents in an urban area, 49% in peri-urban area and 33% in rural area stated that they don't have trust in disaster management authorities. This mistrust is mainly due to a lack of comprehensive disaster awareness and preparedness programs on a community level. Risk perception was also examined in relation to all the areas, and it was found that risk perception varies significantly in urban, peri-urban, and rural areas (t=70.94, p value= 0.000).

Table 4.2 Overall Risk perception Index distribution at the household level

Area	Classes	Very low <(Mean-SD)	Low (Mean-SD) - Mean	Moderate Mean – (Mean+SD)	High >Mean+SD	Total	Statistics	f-test
Urban	Range No of HHs %	<0.43 30 15	0.43-0.58 61 30.5	0.59-0.73 70 35	>0.73 39 19.5	 200 100	Min=.20 Max=.95 Mean=.5814 SD=0.15172	f=70.9 P= 0.000
Peri-urban	Range No of HHs %	<0.3832 20 20	0.39-0.56 29 29	0.57-0.745 32 32	>0.745 19 19	 100 100	Min=.13 Max=.86 Mean=.5642 SD=0.181	
Rural	Range No of HHs %	<.209 23 23	0.209-.0448 28 28	0.49-0.687 27 27	>0.687 22 22	 100 100	Min=0 Max=.90 Mean=.448 SD=.239	
Total	No of HHS %	73 18.25	118 29.5	129 32.25	80 20	400 100		

Graphical distribution of risk perception index is given in figure 4.2

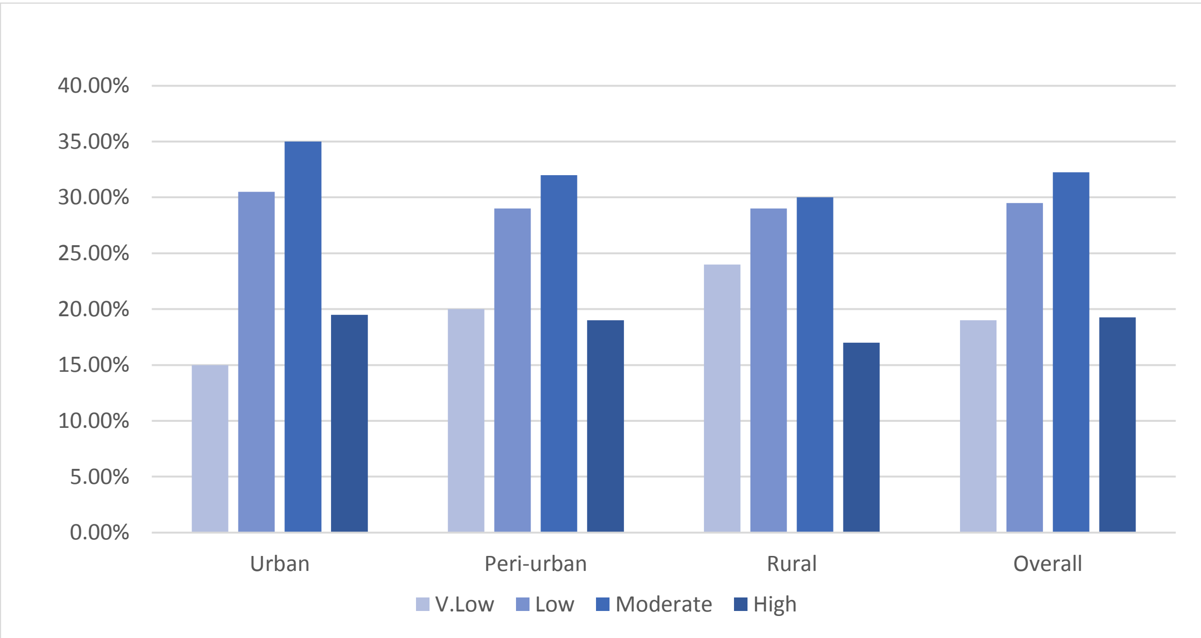

Figure 4.2 Distribution of overall risk perception index

Risk perception is controlled by cultural models as well as a person's own understanding and actions towards disasters. [30]. Indicators affecting risk perception can be broadly categorized into four classes, including fear, awareness, trust, and attitude. Results of descriptive statistics of these classes are explained below:

4.2.1 Individual dimensions of risk perception

4.2.1.1 Fear

Statistics revealed that the highest value of the fear risk perception index was 1 for each area, while the lowest was 0.14 from urban areas. The urban area has the most (20%) respondents having high risk perception due to fear, while the rural area has the lowest (14%) respondents had high fear risk perception. Those who live in urban areas have the most fear of earthquakes and their consequences. The low number of respondents with high fear risk perception may be due to fatalistic attitudes and false religious explanations about natural disasters (Table 4.3). While studying the relation of fear RPI to geographical regions, it was found that results vary significantly in the urban, peri-urban, and rural areas(t=82.25, p value=0.000).

Table 4.3 Fear- Risk perception Index (FRPI) distribution at household level

Area	Classes	Very low <(Mean-SD)	Low (Mean-SD) – Mean	Moderate Mean – (Mean+SD)	High >Mean+SD	Total	Statistics	f-test
Urban	Range No of HHs %	<0.515 28 14	0.515-0.685 78 34	0.69-0.855 54 27	>0.855 40 20	200 100	Min=0.14 Max=1 Mean=0.685 SD=0.170	f=82.7 p= 0.000
Peri-urban	Range No of HHs %	<0.545 17 17	0.545-0.708 30 30	0.71-0.871 35 35	>0.871 18 18	100 100	Min=0.18 Max=1 Mean=0.708 SD=0.163	
Rural	Range No of HHs %	<.0.51 19 19	0.51-0.678 29 29	0.68-0.846 38 38	>0.846 14 14	100 100	Min=0.25 Max=1 Mean=0.678 SD=0.168	
Total	No of HHS %	64 16	137 34.25	127 31.75	72 18	400 100		

Graphical distribution of fear risk perception index is given below in figure 4.3

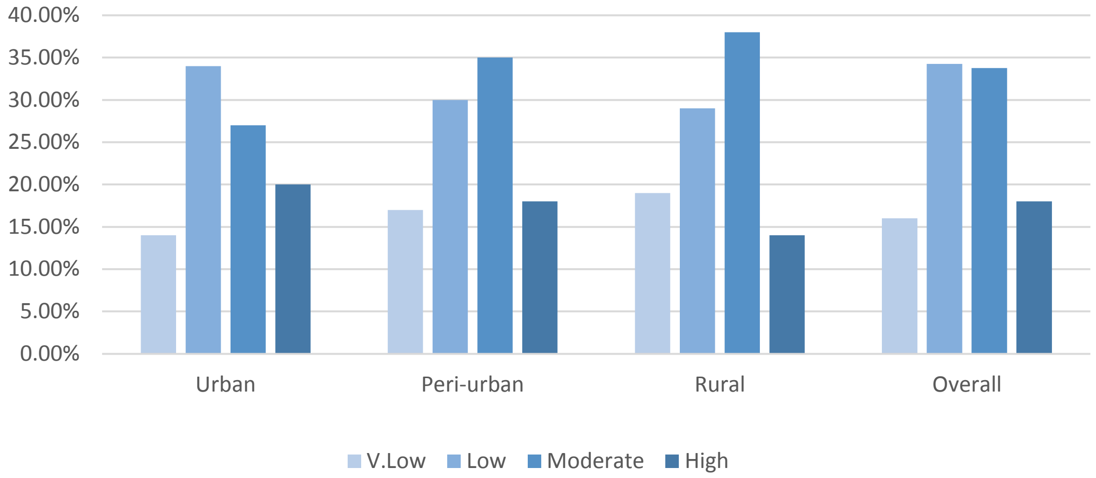

Figure 4.3 Distribution of Fear risk perception index

4.2.1.2 Awareness

Awareness about the nature of seismic events, their basic knowledge, and mitigation strategies have impact on seismic risk perception. Awareness and knowledge are key factors in developing a true understanding of risk perception. Awareness indicators including basic seismic knowledge and precautionary measures were included in risk perception assessment. Analysis about the awareness component of risk perception revealed that most of them (53%) respondents have no knowledge about emergency plans and protocols. Only 8% of the respondents have the view that there will be no earthquake in the future. Results further revealed that only 18% of the total respondents have a high level of awareness about seismic events and precautionary measures, while 24% of the respondents have the lowest level of awareness. These conditions depict that there is no earthquake knowledge and awareness program at the community level. The Peri-urban area had the highest percentage (32%) of respondents at a high level of risk perception due to awareness (Table 4.4). Awareness RPI was found to be varied significantly along with the study areas (t=33.951, p value=0.000).

Table 4.4 Awareness- Risk perception Index distribution at the household level

Area	Classes	Very low <(Mean-SD)	Low (Mean-SD) - Mean	Moderate Mean – (Mean+SD)	High >Mean +SD	Total	Statistics	T-test
Urban	Range No of HHs %	<0.228 59 29.5	0.228-0.516 39 19.5	0.517-0.804 82 41	>0.804 20 10	200 100	Min=0 Max=1 Mean=0.516 SD=0.288	
Peri-urban	Range No of HHs %	<0.143 12 12	0.143-0.464 42 42	0.465-0.785 14 14	>0.785 32 32	100 100	Min=0 Max=1 Mean=0.464 SD=0.321	
Rural	Range No of HHs %	<0.265 25 25	0.265-0.582 15 15	0.583-0.900 39 39	>0.900 21 21	100 100	Min=0 Max=1 Mean=0.582 SD=0.3167	t=33.95 p= 0.000
Total	No of HHS %	96 24	96 24	135 33.75	73 18.25	400 100		

Graphical distribution of awareness risk perception is given below in figure 4.4.

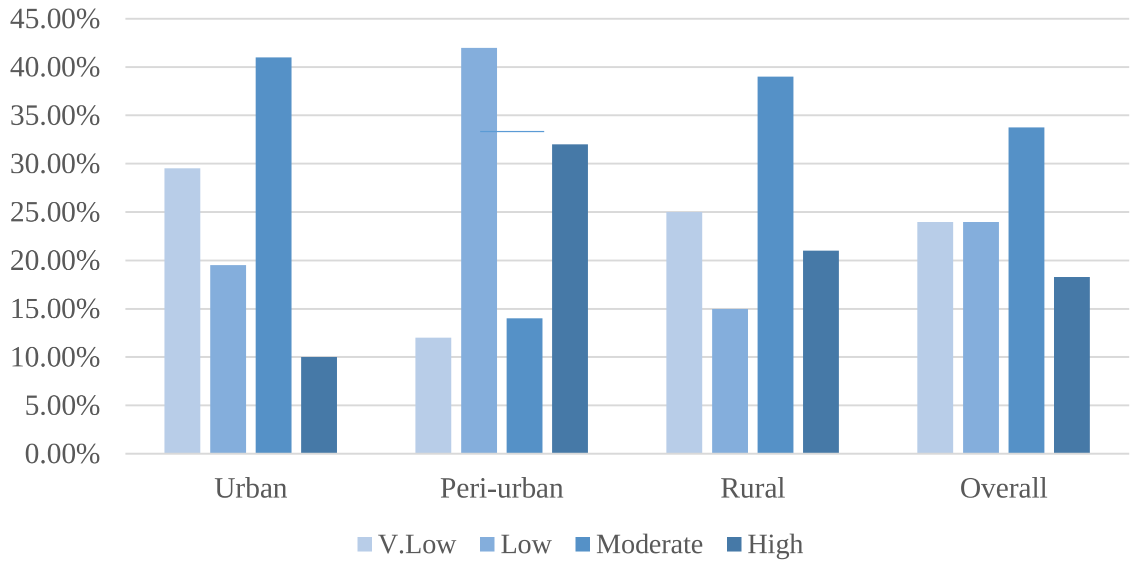

Figure 4.4 Distribution of awareness risk perception index

4.2.1.3 Trust

Trust in disaster science, disaster management authorities, and their strategies strongly impact seismic risk perception. Trust in authorities and knowledge transmitted by media and emergency plans were used for identifying the trust risk perception index. Descriptive statistics revealed that 40% of the overall respondents had a high level of risk perception due to trust. The rural area has the highest number (45%) of respondents with a high level of risk perception due to trust. Risk perception index due to trust had a significant variation in the urban, peri-urban and rural study area (t= 30.692, p value= 0.000) as shown in Table 4.5.

Table 4.5 Trust- Risk perception Index distribution at household level

Area	Classes	Very low <(Mean-SD)	Low (Mean-SD) - Mean	Moderate Mean – (Mean+SD)	High >Mean+SD	Total	Statistics	f-test
Urban	Range No of HHs %	<0.179 48 24	0.179-0.58 33 16.5	0.59-0.981 42 21	>0.981 77 38.5	200 100	Min=0 Max=1 Mean=0.58 SD=0.401	f=30.7 p= 0.000
Peri-urban	Range No of HHs %	<0.189 23 23	0.189-0.593 17 17	0.60-0.997 19 19	>0.997 41 41	100 100	Min=0 Max=1 Mean=0.593 SD=0.404	
Rural	Range No of HHs %	<.0.25 16 16	0.25-0.62 12 12	0.63-0.99 27 27	>0.99 45 45	100 100	Min=0 Max=1 Mean=0.62 SD=0.371	
Total	No of HHS %	87 21.75	62 15.5	88 22	163 40.75	400 100		

Trust risk perception index is graphically shown in figure 4.5 below

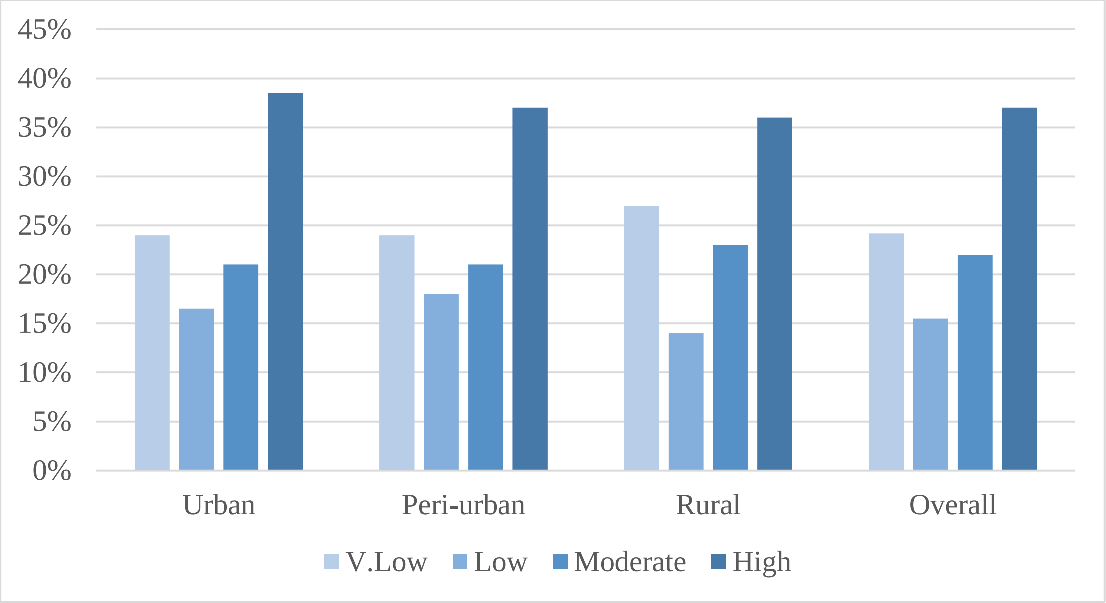

Figure 4.5 Distribution of Trust risk perception index

4.2.1.4 Attitude

Risk perception is governed by the cultural models as well as a person's own observation, understanding, and actions. These personal understandings and behaviors constitute a person's attitude [30]. Indicators used to assess attitude risk perception include the agreement of respondent towards following building code, migration at the time of disaster and fatalistic attitude, etc. Results showed that the urban area has the highest number of respondents (20%) with high risk perception due to attitude. Overall, 16% of the respondents perceived the high risk due to attitude.

Little knowledge about building codes and fatalistic attitudes could be the possible reason for low risk perception due to attitude. Attitude RPI has a significant variation with t= 38.653 and p= 0.000, so it also varies with the study area (Table 4.6).

Table 4.6 Attitude- Risk perception Index distribution at household level

Area	Classes	Very low <(Mean-SD)	Low (Mean-SD) - Mean	Moderate Mean – (Mean+SD)	High >Mean+SD	Total	Statistics	f-test
Urban	Range	<0.214	0.214-0.441	0.45-0.668	>0.668		Min=0	
	No of HHs	18	54	88	40	200	Max=1	
	%	9	27	44	20	100	Mean=0.441 SD=0.227	
Peri-urban	Range	<0.1761	0.176-0.415	0.42-0.654	>0.654		Min=0	
	No of HHs	11	33	37	19	100	Max=1	
	%	11	33	37	19	100	Mean=0.415 SD=0.2389	
Rural	Range	<.0.2798	0.279-0.515	0.52-0.75	>0.75		Min=0	t=38.65 p= 0.000=
	No of HHs	26	42	27	5	100	Max=1	
	%	26	42	27	5	100	Mean=0.515 SD=0.2352	
Total	No of HHS	55	129	152	64	400		
	%	13.75	32.25	38	16	100		

Distribution of Attitude risk perception index is graphically shown in figure 4.6 below.

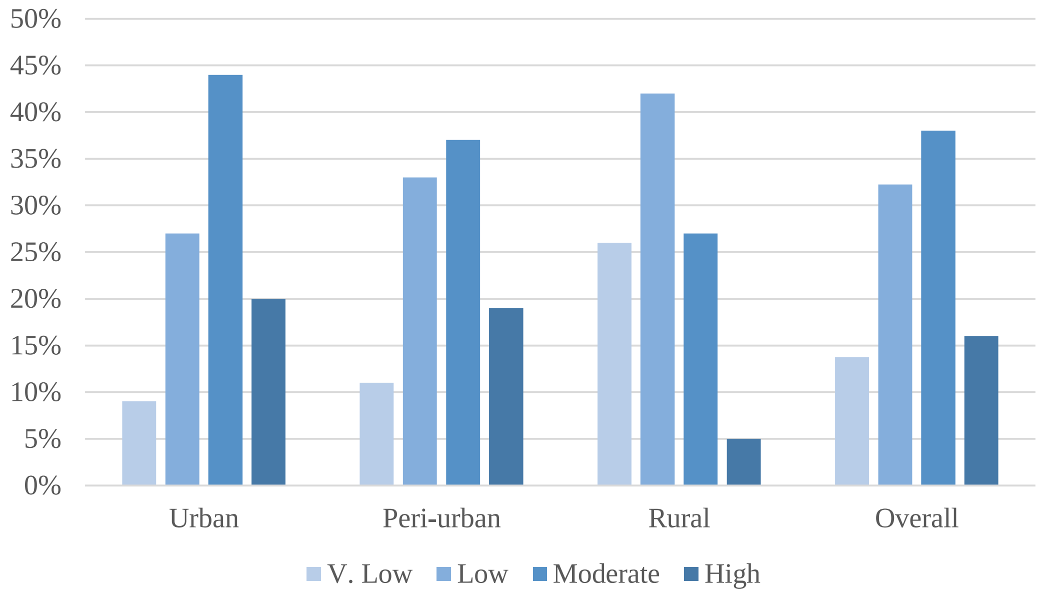

Figure 4.6 Distribution of Attitude risk perception index

4.2.2 A comparison of mean values of RPIs

A comparison of mean values of risk perception indices is shown in table 4.7. Results indicated that all the highest RPIs were from rural area. People risk perception can be improved by raising awareness about disaster science, its precautionary and safety measures. Fatalistic attitudes can be discouraged by a true explanation of religious beliefs by reputed scholars. Low risk perception levels can be improved by increasing awareness programs and active involvement of the public to develop their interest. There always exists a gap between people's risk perception and expert's assessment of risk. This gap is due to differences in knowledge, understanding, and exposure to disaster [53]. The purpose of disaster risk reduction is to reduce this gap and make perceived risk closer to the actual risk. Therefore, disaster management policy could be implemented better [30].

Table 4.7 Average of Risk perception and its subcategories

Region	Mean ORPI	Mean FRPI	Mean AwRPI	Mean TRPI	Mean ARPI
Overall	0.591	0.689	0.520	0.606	0.453
Urban	0.581	0.683	0.499	0.58	0.4413
Peri-urban	0.564	0.678	0.464	0.593	0.414
Rural	0.636	0.708	0.582	0.67	0.515

4.3 Earthquake Preparedness Assessment

Preparedness measures include the steps taken to reduce the adverse effects of disasters [43]. Most of the variations were observed in risk perception were due to the presence of a first aid kit, financial support by family in case of disaster and secured non-structural parts of the house. Descriptive statistics revealed that the maximum value of the risk perception index (RPI) was 0.90 in both rural and urban areas, while it is 0.80 in the peri-urban area. Analysis of preparedness on indicators level revealed that most respondents (54%) have first aid kits in their house, but fire extinguishers were only kept by 4% of the population. Most of the respondents (69%) were able to face stressful situations and calm down others, which symbolizes greater psychological preparedness. Only 25% have an alternate house in a low seismic region, and 38% have a source of income that cannot be affected by the earthquake. Only 10% have taken the earthquake drills, and 26% have tents for accommodation in an emergency. This situation demands a comprehensive earthquake drills program on a community level to enhance the level of preparedness.

Analysis of preparedness index ranges revealed that only 16.5 percent of all respondents have a high level of preparedness. The rural area has the highest number of respondents (22%) at a high level of disaster preparedness. Most of the population (57%) has a very low to low level of disaster preparedness. Such a reduced level of preparedness indicates massive destruction again in case of an earthquake, as the region is highly prone to seismic activities. Results of the f-test revealed that the preparedness index also varies significantly with the study areas (Table 4.8).

Based on descriptive statistics, it can be said that most of the population is on low preparedness, which means in case of an earthquake, there will be increased damage to lives and assets. There should be specified topics included in the curriculum regarding preparedness and awareness measures. There should be an evacuation plan for each building and an emergency plan for each community. First aid kits and tents should be provided for emergency needs. Psychological aspects of preparedness should also be addressed. Disaster management authorities should interact with the people and build their interest in preparedness programs, because no preparedness measures could be adopted without a sense of belonging and active participation of the public.

Table 4.8 Preparedness Index distribution at household level

Area	Classes	Very low <(Mean-SD)	Low (Mean-SD) – Mean	Moderate Mean – (Mean+SD)	High >Mean+SD	Total	Statistics	f-test
Urban	Range No of HHs %	<0.242 33 17.5	0.242-0.436 84 42	0.437-0.629 52 26	>0.6294 29 14.5	200 100	Min=0 Max=0.90 Mean=0.436 SD=0.1934	t=41.54 p= 0.000
Peri-urban	Range No of HHs %	<0.205 10 10	0.205-0.409 50 50	0.410-0.612 25 25	>0.6125 15 15	100 100	Min=0 Max=0.80 Mean=0.409 SD=0.2035	
Rural	Range No of HHs %	<0.208 12 12	0.208-0.448 39 39	0.449-0.6873 27 27	>0.6873 22 22	100 100	Min=0 Max=0.90 Mean=0.448 SD=0.2393	
Total	No of HHS %	55 13.75	173 43.25	104 26	66 16.5	400 100		

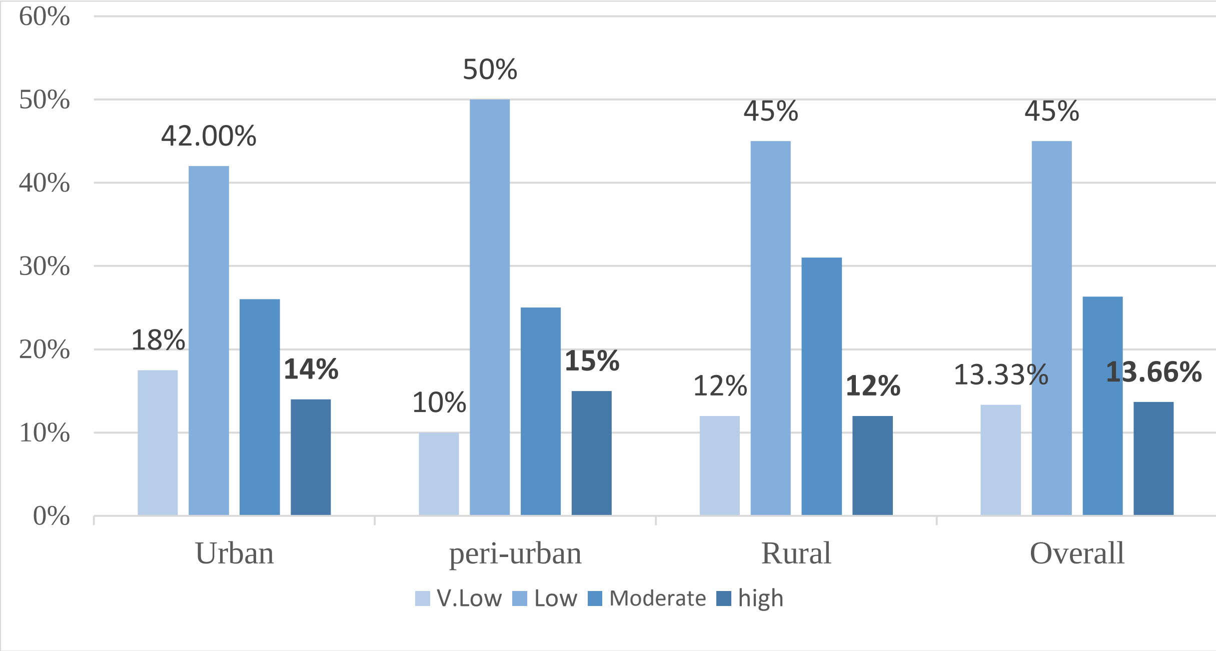

Figure 4.7 Distribution of overall preparedness index

4.4 Physical Vulnerability Assessment

Physical vulnerability is the potential of a building to suffer damage against earthquakes. Most of the variation in physical vulnerability was observed due to presence of cracks in the structures, type of structures and claddings attached on the structures. 51% of the total houses are load bearing structures. 11% of the houses have heavy cladding on their exterior walls. 13% of the overall houses have structural cracking. 50% of the houses have block, 14% have brick and 36% have stone masonry. 33% of the overall houses require maintenance. 47% of the overall houses have been altered either horizontally or vertically. 41% of the houses have irregular plan configuration.

Descriptive analysis of overall physical vulnerability index revealed that average value of overall vulnerability index is 0.45, while the maximum and minimum values are 0.75 and 0.18 respectively. Average value for urban area is 0.44, while maximum and minimum values are 0.75 and 0.19 respectively. Peri-urban area has an average value of 0.48, maximum value of 0.75 and minimum value of 0.30. Rural area has 0.46, 0.75 and 0.24 as its average, maximum and minimum values respectively.

51.5% of the houses in urban area were found to be in range of very low to low vulnerability, while 22.5% houses were found to be highly vulnerable. In peri-urban area 45% of the houses were in the range of very low to low vulnerability and 30% houses were found to be highly vulnerable. In rural area 54% of the houses were found to be very low to low vulnerable. 37% of the rural houses were found to be highly vulnerable. Probably the main reason of large number of highly vulnerable houses is use of stone for masonry purposes. In rural areas stone is abundant and used widely. Another possible reason is presence of pre-earthquake houses. Houses constructed before earthquake of October 2005, are mostly unreinforced, load bearing and cracked due to aging and earthquake effects. The descriptive analysis of physical vulnerability is presented in table 4.9.

Table 4.9 Physical vulnerability Index distribution at household level

Area	Classes	Very low <(Mean-SD)	Low (Mean-SD) – Mean	Moderate Mean – (Mean+SD)	High >Mean+SD	Total	Statistics	t-test
Urban	Range No of HHs %	<0.3392 31 15.5	0.337-0.44 72 36	0.44-0.541 54 27	>0.541 43 22.5		Min=0.19 Max=0.75 Mean=0.440 SD=0.101	t=41.54 p= 0.000
Peri-urban	Range No of HHs %	<0.3812 12 12	0.381-0.487 33 33	0.487-0.57 25 25	>0.57 30 30		Min=0.30 Max=0.75 Mean=0.487 SD=0.106	
Rural	Range No of HHs %	<0.3374 14 14	0.337-0.453 40 40	0.453-0.60 9 9	>0.60 37 37		Min=0.24 Max=0.75 Mean=0.453 SD=0.116	
Total	No of HHS %	57 14.25	145 36.25	88 22	110 27.5			

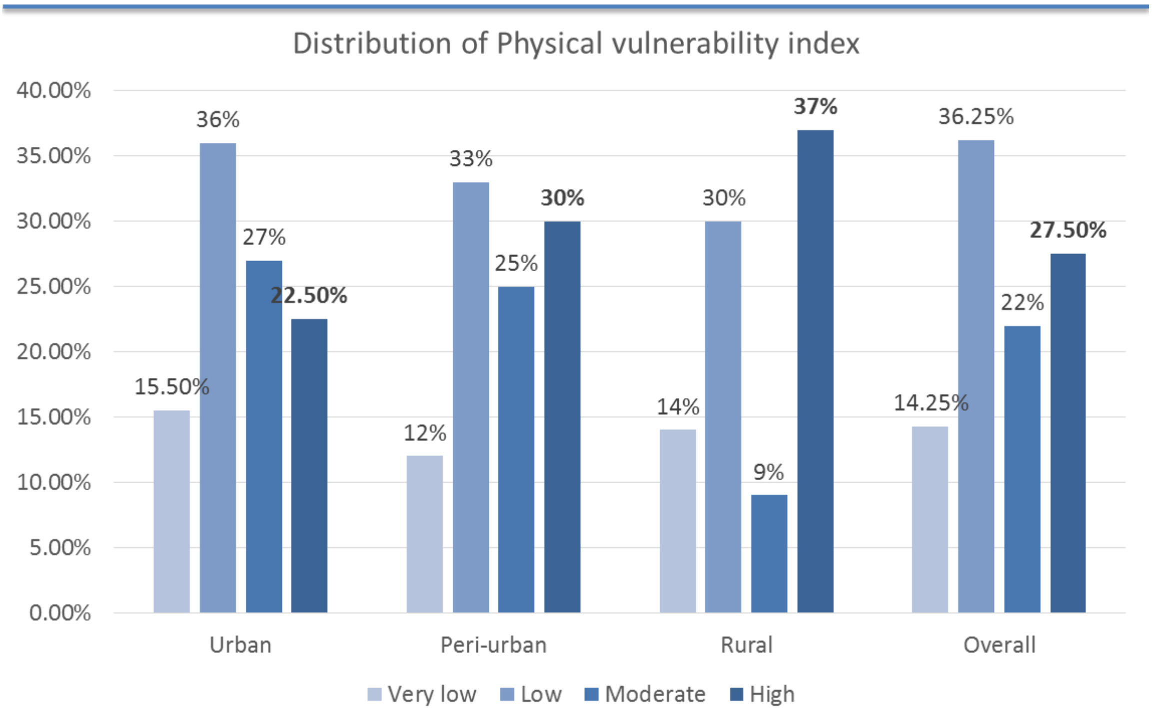

Figure 4.8 Distribution of physical vulnerability index

4.4.1 Key features of the construction practices to be improved

During the field survey some features of the construction practices were observed that tend to increase the physical vulnerability of the houses. Therefore such malpractices should be avoided in future construction. Some of the houses had irregular shapes or complex geometry (Figure 4.9). These house show poor performance during earthquake. In future construction regularity of house plan should be considered.

Figure 4.9 A house with plan irregularities.

It was observed in all the three study areas that a considerable number of houses have hollow pre-cast ornamental columns that were used for load bearing purposes (Figure 4.10). Use of such columns gives reduction in cost and time of construction, but at the same time compressive strength of column is reduced considerably. So the structural performance of these columns in earthquake in very poor. These columns must be replaced with in-situ (solid) reinforced concrete columns.

Figure 4.10 A multi-story house having hollow Ornamental columns as major load carrying members.

Among urban, peri-urban and rural houses, a significant number of houses had flat slabs in verandahs and terraces. Flat slabs are used for cost reduction and ease of construction (Figure 4.11). But due to their low punching shear capacity, such slabs are prohibited in earthquake prone regions. These slabs should be avoided as these result in increased vulnerability of buildings.

Such types of flat slabs should not be used in garages and porches too.

Figure 4.11 A two story house with flat slabs in verandahs

Rural areas have some houses with earthen roof and stone masonry walls. Stone masonry walls are laid using mud mortar (Figure 4.12). Earthen roof has thickness greater than 1 feet. So stone masonry and thick earthen roofs tends to increase the weight of structure. The structure with heavy mass and lack of integration between its members fails even in a low intensity earthquake. Such houses should be replaced by ‘’Dhajji construction’’. (Dhajji construction is an economical alternative of earthen houses. In dhajji construction walls are constructed using stones and mud mortar. Stone masonay is confined by placing a closely spaced wooden frame in the walls.) Dhajji construction is a low cost residential solution so it is used in those rural areas where people have poor economic status. This type of construction uses locally available materials.

Figure 4.12 An Adobe house in the rural study area.

Usually columns are present in verandahs and balconies. Considerable number of houses had partial masonry in the verandahs for safety and privacy purposes (Figure 4.13). Due to this partial masonry column behaves as a short column during earthquake. Short columns attract more seismic forces and fail. So partial masonry should be avoided and could be replaced by grills.

Figure 4.13 A house with partial masonry infills/ short column effects.

Many of the houses in rural and peri-urban areas have horizontal or vertical attachments. These attachments are usually additional rooms for storage or living etc (Figure 4.14). These are constructed after construction of the house, so these are not integral part of the houses. So usually a failure plane is developed even due to low intensity earthquake. If it is necessary to make an attachment it should be properly anchored to the structure.

Figure 4.14 A house with horizontal attachment.

Construction on slopes should be avoided in regions prone to earthquake. As Rawalakot is a hilly area so flat grounds are not available for construction, therefore people usually construct on toes of hills or ridges. Such type of construction should be avoided (Figure 4.15).

If it is unavoidable to construct on slopes, then slopes should be stabilized using slope stabilization techniques like plantation, benching of slopes, rip-rap bedding and constructing retaining walls etc.

Figure 4.15 A house constructed on sloppy site

It is a common practice to reuse debris or old construction material for new construction. Old construction materials have used most of their strength during their service life and in dismantling. So using such a type of material will result in less strength of members (Figure 4.16). Old construction material should be used only for non-structural purposes.

Figure 4.16 A house constructed using old/used constructed material.

4.5 Impact of Risk Perception on Preparedness Measures

The Pearson's correlation approach was employed to assess the association between risk perception and preparedness. Results revealed that there occurs a significant positive correlation between risk perception and preparedness. The value of the overall correlation coefficient 'R' is 0.515 indicates the relation is not so strong. The strongest association was found in a peri-urban region with R = 0.594, while for urban and rural areas, R values are 0.456 and 0.530, respectively. Dimensions of risk perception also had a weak significant positive correlation with preparedness (Table 4.10).

Linear regression analysis was used to determine the impact of risk perception (independent variable) on preparedness (independent variable). Results of the linear regression model revealed that risk perception influences preparedness in all three study areas. Preparedness measures are increased as the risk perception increases. Theoretically, risk perception of people influences the preparedness measures taken by them, but not vice versa as shown in figure . The influence of subcategories of Risk perception on preparedness was also observed. The strongest relationship was found for the awareness subcategory (R=0.497). Low values of r indicated that trust, fear and attitude subcategory have little influence on preparedness measures. The results of Pearson correlation and linear regression analysis are summarized in Table 4.10.

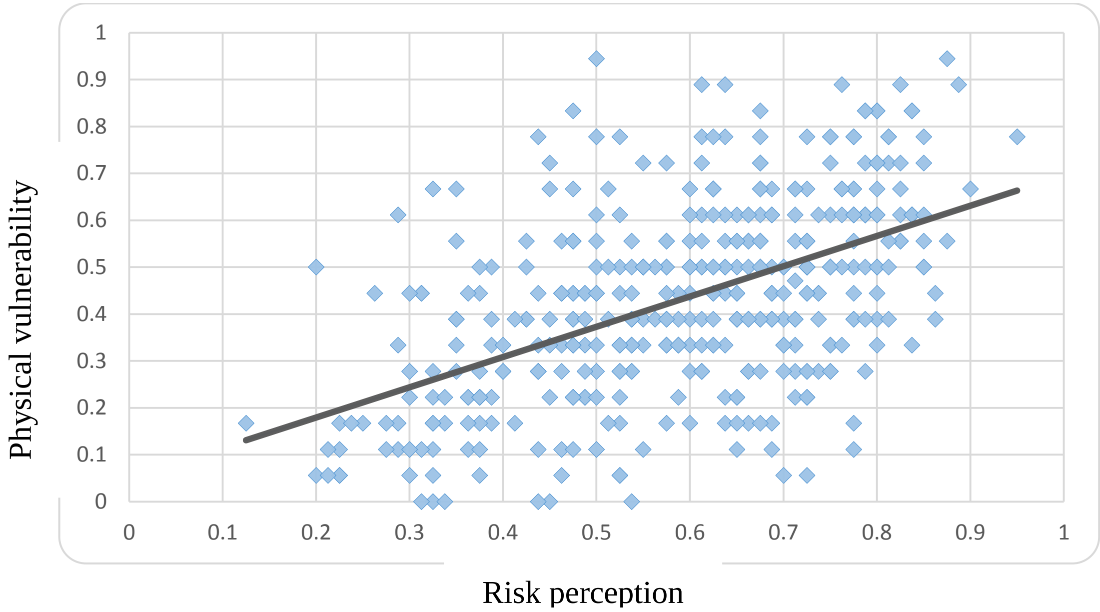

Figure 4.17 Relationship between earthquake preparedness and risk perception

Although a significant positive association exists between risk perception and preparedness, this relationship cannot be perfect, as there are many other factors that directly or indirectly affect both risk perception and preparedness. Knowledge, response efficacy, and behavior also have an influence on preparedness. So risk perception is necessary, but not the only cause of preparedness. Income and resources also affect the preparedness measures. Face-to-face interviews with the respondents revealed that the disaster management authorities had not conducted any preparedness program or awareness trainings on a community level, despite being a highly prone earthquake region. Mistrust to the authorities and fatalistic behavior together affect the risk perception of the people and thus preparedness measures too. There is a need to educate and train people about the earthquake, evacuation plans, safety practices, and emergency behaviors to improve risk perception and thus preparedness. Increased preparedness will result in fewer damages in a future earthquake.

Table 4.10 Relationship between risk perception and preparedness

Areas	R	F	R2	Df	P-value	B	A	Empirical relationship PI= B + Arpi
Overall	0.515	143.4	0.265	1	0.000	0.052	0.643	PI=0.052+ 0.643*ORPI
Urban	0.456	51.78	0.208	1	0.000	0.01	0.581	PI=0.01+ 0.581*URPI
Periurban	0.594	53.35	0.353	1	0.000	0.032	0.668	PI=0.032+ 0.668*PRPI
Rural	0.530	38.30	0.281	1	0.000	-0.019	0.734	PI=-0.019+0.734*RRPI

Table 4. 11 Relationship between dimensions of risk perception and preparedness

Dimensions	R	F	R2	Df	P-value	B	A	Empirical relationship PI= B + αRPI
Fear-RPI	0.166	11.33	0.028	1	0.000	0.290	0.206	PI= 0.290+0.206*TRPI
Aw.-RPI	0.497	130.85	0.247	1	0.000	0.257	0.338	PI= 0.257+0.338*ARPI
Trust-RPI	0.352	56.43	0.124	1	0.000	0.320	0.19	PI=0.320+ 0.19*TRPI
Atti-RPI	0.264	29.71	0.069	1	0.000	0.326	0.234	PI=0.326+0.326*At.RPI

4.6 Impact of Physical Vulnerability on Risk Perception

Pearson correlation approach was used to define the linkage between physical vulnerability and risk perception. Results revealed that there exists a negative correlation between physical vulnerability and risk perception for overall, rural and urban areas. This negative relation indicates that if the physical vulnerability increases, risk perception will decrease but not vice versa. Significant and negative correlation between risk perception and physical vulnerability employs that community will not adopt preparedness measures against earthquakes. The value of correlation coefficient R for overall area is -0.047 reveals that the relationship is not so strong. The value of correlation coefficient R for urban and rural are -0.068 and -0.077 respectively, which indicates their relation is also weak.

The relationship between physical vulnerability and risk perception for peri-urban area is significantly positive. Therefore if the physical vulnerability increases, risk perception also increases. But theoretically it is impossible that increase in risk perception results in increased physical vulnerability. This positive relationship indicates that people may tend to adopt preparedness measures, against future earthquake hazards.

The relationship between risk perception and physical vulnerability can't said to be perfect, as there are many other factors that also influence risk perception and physical vulnerability. The effects of other factors should be investigated thoroughly. This indicates that people are very less inclined towards adopting preparedness measures. Risk perception is not the actual risk, but it is the picture of risk in minds of people. Risk perception can be improved by initiating seismic risk awareness programs. Relevant authorities should educate people about seismic risk, emergency planning, building codes, earthquake resistant designs and preparedness measures, in order to prepare an earthquake resilient community.

Table 4.12 Relationship between physical vulnerability and risk perception

Areas	R	F	R2	Df	P-value	B	A	Empirical relationship RPI= B + Apvi
Overall	-0.047	0.875	0.002	1	0.000	0.622	-0.07	RPI=0.62-0.07*PVI
Urban	-0.068	0.931	0.005	1	0.000	0.623	-.094	RPI= 0.623-0.094 *PVI
Periurban	0.068	0.460	0.005	1	0.000	0.505	0.117	RPI=0.505+ 0.117*PVI
Rural	-0.077	0.581	0.006	1	0.000	0.687	-0.114	RPI=0.687-0.114*PVI

4.7 Summary of the Chapter

From results it can be concluded that majority of the population is at moderate level of risk perception. While risk perception is most in urban study area. Risk perception due to trust awareness and awareness is highest in urban area, while risk perception due to fear is highest in rural areas.

Risk perception positively influences preparedness measures and this relation is strongest in [eri-urban area. Physical vulnerability positively influences risk perception, and this relation is strongest in peri-urban area. But these relations can't said to be perfect, as there are many other factors that influence these indicators.

5. CONCLUSIONS AND RECOMMENDATIONS

5.1 Conclusions

The study examined seismic risk perception and level of preparedness against earthquakes in Rawalakot, AJ&K, along with the linkage among the risk perception and preparedness using primary data. This study also linked the dimensions (fear, trust, awareness and attitude) of risk perception with preparedness. These studies are missing in disaster risk literature. This study also provides a detailed procedure to find the linkage between risk perception and physical vulnerability.

- Results revealed that the level of education and income was satisfactory in all three study areas.
- A significant variation was observed in all three areas, mainly due to fear of future earthquakes, expected losses, and expected breakdown of supplies.
- Most of the respondents believed that there would be an earthquake in the future, but still very little of total respondents took precautionary measures.
- Fatalistic attitude towards disaster could be the main cause of low preparedness.
- Although Rawalakot has faced a massive earthquake of Mw 7.6 in 2005, but still most of the respondents (73%) believe that this is a non-seismic zone. This situation indicates poor understanding of people about the seismicity of region.
- 45% of the people in urban, 49% in peri-urban, and 33% in rural population have mistrust in authorities. The role of disaster management authorities is questioned, and it could be improved by the initialization of community-level preparedness and awareness programs. Most of the population was at very low to low levels of fear, awareness, trust, and attitude perception indices.
- Preparedness was significantly varying mainly due to fear of pre-earthquake 2005 (vulnerable) structures, belief that houses will not resist the expected earthquake, and trust in emergency planning.
- Most of the population (57%) was found to be at a very low to low level of preparedness, probably due to lack of awareness and resources required.
- The relationship between risk perception (independent variable) and preparedness (dependent variable) was found to be significantly positive, but the strength of the relationship was not so strong (r=0.514). For urban, peri-urban, and rural areas, it was proved that risk perception influences preparedness.

- Among the subcategories of risk perception, awareness had the strongest influence on risk perception. The relation between risk perception and preparedness cannot be said to be conclusive, as many other factors also influence preparedness. The results of this study are consistent with the research done on US hospitals [19].
- This study will be highly helpful for disaster management authorities, administrative staff, and other relevant professionals to get more insight into risk perception and preparedness for each study area in context to their socio-economic conditions. So, the outcomes of this study area can be used to design risk awareness and disaster preparedness policies at the community level with the active involvement of people.
- Although this study tries its best to access risk perception, preparedness, and association, it could be further improved by increasing the indicators of risk perception and preparedness. Like subcategories of risk perception, preparedness can also be divided into subcategories and correlation of these can be studied. As the relationship between risk perception and preparedness is not 'exact', so the role of other factors like response efficacy etc., should also be studied. This study can be used in any earthquake-prone region and other hazards by adjusting the relevant indicators.

5.2 Recommendations

Following recommendations are made based upon observations and conclusions of this study.

- Future researchers can include factors including presence of architectural columns as load bearing members, cantilever construction and presence of flat plates and flat slabs for estimation of physical vulnerability in future.
- As our studies indicated that relationship between risk perception and preparedness is not "exact", so some other factors may also influence preparedness. These factors should be investigated in future studies.
- Basic knowledge about awareness of disasters should be included in curriculum.
- Public awareness programs about disaster risk reduction should be initiated.
- Local building codes for urban, peri-urban and rural study areas can be prepared based on physical vulnerability data.
- Catalogue consisting of all types of residential buildings can be prepared using available physical vulnerability data.

- A considerable number of buildings are partially damaged due to earthquake of October 2005, these buildings require retrofitting to restore their strength. Retrofitting techniques can be designed using physical vulnerability data.
- Earthquake preparedness data can be used for making compensations in case of losses resulted in a disaster.

REFERENCES

1. Ş. Ersoy & A. Koçak Disasters and earthquake preparedness of children and schools in Istanbul, Turkey,(2016) Geomatics, Natural Hazards and Risk, 7:4, 1307-1336, DOI: 10.1080/19475705.2015.1060637
2. L.S. Kramer, ‘ Geotechnical earthquake engineering’ (1996), Environmental and engineering geoscience, upper saddle river, NJ: Prentice hall
3. M.C. Ningthoujam et al, Rapid visual screening procedure of existing building based on statistical analysis International Journal of Disaster Risk Reduction (2018),https://doi.org/10.1016/j.ijdrr.2018.01.033
4. A.H. Kazmi and R.A. Rana, ‘Tectonic map of Pakistan: Ministry of Petroleum and Natural Resources’, (1982) *Geological Survey of Pakistan*
5. A. Hussain, R.S. Yeats, M. Lisa, Geological setting of the 8th october 2005 Kashmir earthquake, (2009) J. Seismol. 13 (3),315–325.
6. M.S. Hossain, Vulnerability Due to Natural Hazards in South Asia: a GIS Aided Characterization of Arsenic Contamination in Bangladesh, (2002).
7. A. Adnan, P. Tiong, R. Ismail, S. Shamsuddin, Artificial neural network application for predicting seismic damage index of buildings in Malaysia (2012). Electro J Struct Eng 12(1):1–9
8. S. Ainuddin, J. Kumar Routray, Institutional framework, key stakeholders and community preparedness for earthquake induced disaster management in Baluchistan, Pakistan (2012) vol. 21 22-36 DOI 10.1108/09653561211202683
9. R. Bilham, The seismic future of cities, Bull. Earth. Eng. 7 (2009) 839. https://doi. org/10.1007/s10518-009-9147-0.
10. P. Slovic Perception of risk. Science, 1987; 236:280–285.
11. A. C. Club & J. Hinkle, Protection motivation theory as a theoretical framework for understanding the use of protective measures (2015) DOI= http://dx.doi.org/10.1080/1478601X.2015.1050590
12. S. Tekeli-Yes¸il, N. Dedeoglu, C. Braun-Fahrlaender, M. Tanner, Earthquake awareness and perception of risk among the residents of Istanbul, Nat. Hazards 59 (2011) 427–446. https://doi.org/10.1007/s11069-011-9764-1
13. Y. Lo Alex and T.O. Lewis, Seismic risk perception in aftermath of Wenchuan earthquakes in Southwest China (2015) Nat Hazards 78: 1979-1996 DOI: 10.1007/S11069-015-1815-6
14. P.Rautela Indigenous technical knowledge inputs for effective disaster management in the fragile himaliyan ecosystem (2005) doi:10.1108/09655356051059527
15. S. Rajarathnam, A.R. Santhakumar, Assessment of seismic building vulnerability based on rapid visual screening technique aided by aerial photographs on a GIS platform, Nat. Hazards 78 (2015) 779–802. https://doi.org/10.1007/s11069-0 14-1382-2.
16. T. Maqsood, M. Adwards, I. Ionanou, Seismic vulnerability functions for Australian buildings by using GEM empirical vulnerability assessment guidelines (2015).
17. G.C. Joshi et al, Seismic vulnerability assessment of lifeline buildings in Himalayan Province of Uttrakhand in India, (2019), DOI: https://doi.org/10.1016/j.ijdrr.2019.101168

18. M.C. Ningthoujam, R.P. Nanda, Rapid visual screening procedure of existing building based on statistical analysis, Int. J. Disaster Risk Reduct. 28 (2018) 720–730. https://doi.org/10.1016/j.ijdrr.2018.01.033.
19. V. Silva, S. Pereira, Assessment of physical vulnerability and potential losses of buildings due to shallow slides (2014), DOI 10.1007/s11069-014-1052-4
20. J. Santos-Reyes , T. Gouzeva, G. Santos-Reyes, "Earthquake Risk Perception and Mexico City‟s Public Safety.(2014)" Procedia Engineering 84: 662–71. https://doi.org/10.1016/j.proeng.2014.10.484.
21. J. Mulilis, T.S. Duval, and R. Lippa The Effects of a Large Destructive Local Earthquake on Earthquake Preparedness as Assessed by an Earthquake Preparedness Scale (1990). *Natural Hazards 3,* 357–371
22. Y. Hong, J. Kim, L. Xiong, Media exposure and individuals emergency preparedness behaviors for coping with natural and human made disasters (2019).
23. D. Every, J. McLennan, A. Reynolds, J. Trigg, Australian householders psychological preparedness for potential natural threats: An exploration of contributing factors (2019).
24. S. Ainuddin, J. Kumar Routray, S. Ainuddin, People's risk perception in earthquake prone Quetta city of Baluchistan, Int. J. Disaster Risk Reduct. 7 (2014) 165–175. https://doi.org/10.1016/j.ijdrr.2013.10.006
25. Pakistan Meteorological Department (PMD) (2007), Seismic hazard analysis and Zonation for Pakistan, PMD, Azad Jammu and Kashmir.
26. L.A Owen, M. Bauer Landslides triggered by October 2005 Kashmir earthquake, (2008) doi: org/10.1016/j.geomorph.2007.04.007
27. A. Naseer, A.N. Khan, Z. Hussain, Q. Ali, Observed seismic behavior of buildings in northern Pakistan during the 2005 Kashmir earthquake, Earthq. Spectra 26 (2010) 425–449. https://doi.org/10.1193/1.3383119
28. M. Shabbir, J. Ilyas M. Development and adoption of building code of Pakistan. In: Proceeding of the cement based material and civil infrastructures, international workshop Karachi, Pakistan; 2007.
29. District disaster management authority, Rawalakot, Annual report 2018
30. L. Sjoberg, Risk perception by the public and by experts: a dilemma in risk management, Hum. Ecol. Rev. (1999) 1–9.
31. M.R. Sadat, M.S. Huq, M.A. Ansary, Seismic vulnerability assessment of buildings of Dhaka city, J. Civ. Eng. 38 (2010) 159–172.
32. S.U. Khan, M.I. Qureshi, I.A. Rana, A. Maqsood, An empirical relationship between seismic risk perception and physical vulnerability: A case study of Malakand Pakistan (2019), https://doi.org/10.1016/j.ijdrr.2019.101317
33. T. Roundmo Risk perception and safety on offshore petroleum plate forms—Part 1:perception of risk (1992):39–52151992: 39–52
34. O. Renn, Risk Governance: Coping with Uncertainty in a Complex, World. London, UK Earthscan Ltd, (2008)
35. S. Jasanoff , The political science of risk perception (1998) vol 59, 91-98 doi=10.1016/50951-8320(97)00129-4

36. G. Washinger, O. Renn, C. Begg, and C. Kuhlicke The Risk perception paradox-Implications of governance and communication of natural hazards (2013) Risk analysis vol 33, No 6. DOI: 10.1111/j.1539-6924.2012.01942.x
37. P. Bubeck,W.J. Botzen and J. C. Aerts , A review of risk perceptions and other factors that influence flood mitigation behaviour (2012a). Risk Analysis 32(9): 1481–1495.
38. Iqbal S, Nasir S, Hussain A (2004) Geological map of the Nauseri area, District Muzaffarabad, AJK: Geol. Survey of Pakistan Geological Map Series v. VI, no. 14, Sheet No.43 F/11, 1:50,000
39. M.K. Lindel, C.S. Prater Household adoption of seismic hazard adjustments: A comparison of residents in two states. (2000) Inernational Journal of Mass Emergencies and Disasters 18: 317-338
40. R. Miceli, I. Sotgiu, M. Settanni, Disaster preparedness and perception of flood risk: A study in an alpine valley in Italy (2008).
41. M. Dyer, K. Inglis, D.Robinson, E.Sajor & C. Williams, A study of earthquake preparedness (1999)
42. L. Armas, Social vulnerability and seismic risk perception. Case study: the historic centre of Bucharest Municipality Romania (2008) DOI 10.1007/s11069-008-9229-3
43. R.J. Burby, P.J. May, Making building codes an effective tool for earthquake hazard mitigation, Glob. Environ. Chang. B Environ. Hazards 1 (1999) 27–37. https://doi.org/10.3763/ehaz.1999.0104
44. SK Jain, C. N. Nigam, Historical developments and current status of earthquake engineering in India. In: Proceedings of the twelfth world conference on earthquake engineering. Auckland, New Zeal- and; 2000.
45. A. Taylan, Factors influencing homeowners' seismic risk mitigation behavior: a case study in Zeytinburnu district of Istanbul, Int. J. Disaster Risk Reduct. 13 (2015) 414–426. https://doi.org/10.1016/j.ijdrr.2015.08.006
46. S. F. Aliabadi, A. Sarsangi, E. Modiri, The social and physical vulnerability assessment of old texture against earthquake. (Case study: Fahadan district in Yazd city) (2014), DOI 10.1007/s12517-015-1939-8
47. I. A. Rana and J. K. Routray, Actual vis-à-vis Perceived Risk of Flood Prone Urban Communities in Pakistan, *International Journal of Disaster Risk Reduction, (2016)* http://dx.doi.org/10.1016/j.ijdrr.2016.08.028
48. A. Ocal, Y. Topkaya Earthquake preparedness in schools in seismic hazard regions in the South-East of Turkey (2011) DOI: DOI 10.1108/09653561111141754
49. S. Ainuddin, Institutional framework, key stakeholders and community preparedness for earthquake induced disaster management in Balochistan (2012), DOI 10.1108/09653561211202683
50. S. Morrissey, J. Reser, Evaluating the effectiveness of psychological preparedness advice in community cyclone preparedness materials (2003), Aust. J. Emerg. Manag. 18 (2)
51. R. Murnane, A. Simpson, B. Jongman, Understanding risk: what makes a risk assessment successful? Int. J. Disaster Resil. Built Environ. 7 (2016) 186–200. http s://doi.org/10.1108/ijdrbe-06-2015-0033.

52. R. Vicente, S. Parodi, S. Lagomarsino, H. Varum, J.A.R.M. Silva, Seismic vulnerability and risk assessment: case study of the historic city centre of Coimbra, Portugal, Bull. Earthq. Eng. 9 (2011) 1067–1096. https://doi.org/10.1007/s10 518-010-9233-3.
53. H. Sucuoglu, U. Yazgan, Simple survey procedures for seismic risk assessment in urban building stocks, in: Seism. Assess. Rehabil. Exist. Build., Springer, 2003, pp. 97–118. https://doi.org/10.1007/978-94-010-0021-5_7.
54. G. Achs, C. Adam, Rapid seismic evaluation of historic brick-masonry buildings in Vienna (Austria) based on visual screening, Bull. Earthq. Eng. 10 (2012) 1833–1856. https://doi.org/10.1007/s10518-012-9376-5.
55. T.M. Ferreira, R. Vicente, J.A.R.M. Da Silva, H. Varum, A. Costa, Seismic vulnerability assessment of historical urban centres: case study of the old city centre in Seixal, Portugal, Bull. Earthq. Eng. 11 (2013) 1753–1773. https://doi. org/10.1007/s10518-013-9447-2.
56. M. lnel, S.M. Senel, S. Toprak, Seismic vulnerability assessment of buildings in urban areas: a case study of Denzili, Turkey (2013) Nat Hazards (2008) 46:265–285, DOI 10.1007/s11069-007-9187-1
57. Azad Jammu & Kashmir At A Glance 2017,Public by Department of planning and development AJ&K, available at http://pndajk.gov.pk
58. S. U. Khan, M. I. Qureshi, I. A. Rana, Ahsan Maqsoom, An empirical relationship between seismic risk perception and physical vulnerability: A case study of Malakand, Pakistan (2019) https://doi.org/10.1016/j.ijdrr.2019.101317
59. H. Zulch, Psychological preparedness of natural hazards ------- improving disaster preparedness policy & practice. doi: https://doi.org/1 0.1111/0272-4332.213124
60. S. Ainuddin , J.K. Routray & S. Ainuddin 'Operational indicators for assessing vulnerability and resilience in the context of natural hazards and disasters', (2015) *Int. J. Risk Assessment and Management*, Vol. 18, No. 1, pp.66–88.

Appendix A Respondent's data collection form

Survey form "Annex A" for Collecting Socio-economic data, risk perception and preparedness data of respondents.			
Sr. No:	Screener: GPS Co-ordinates	Date/Time:	Region:
1 Gender :(جنس)	2 Age: (عمر)	3 Education(تعلیم):	4 Occupation: (پیشہ)

5 House :(گھر) 1. Owned(ذاتی) 2. Rented (کرایہ پر)	6 Household size (کنبہ کی تعداد)	7 Avg. monthly income: (اوسط ماہانہ آمدنی)

8 No of educated persons in house? گھر میں پڑھے لکھے افراد کی تعداد؟	9 No of households doing job? گھر میں ملازمت پیشہ افراد کی تعداد؟
10 Occupation of household head? کنبے کے سربراہ کا پیشہ؟	11 Year of residency in this house? (کتنے عرصے سے اس گھر میں رہائش پذیر ہیں؟)
12 Is there any expectancy of earthquake in future? (کیا آپ کے نزدیک مستقبل میں زلزلے آنے کا امکان ہے؟)	13 Reason of earthquake? (آپ کے نزدیک زلزلے آنے کی بنیادی وجہ؟)
14 No of patients present at home? (گھر میں موجود مریضوں کی تعداد؟)	15 No of children present at home? (گھر میں موجود بچوں کی تعداد؟)

16 What is the level of expected earthquake? (آپ کے نزدیک متوقع زلزلے کے شدت کیا ہوگی؟)	1. High(زیادہ)	2. Moderate(درمیانہ)	3. Low (کم)
17 How much you are afraid of earthquakes? (آپ زلزے سے کس قدر خوف زدہ ہیں؟)	1. High(زیادہ)	2. Moderate(درمیانہ)	3. Low (کم)
18 what will be the extend of damage of lives and assets? (مستقبل میں کسی زلزلے کی صورت میں انسانی جانوں اور املاک کا ضیاع کس قدر ہوگا؟)	1. High(زیادہ)	2. Moderate(درمیانہ)	3. Low (کم)
19 How frequently you think about seismic events? (آپ زلزلے کے بارے میں کس قدر سوچتے ہیں؟)	1. Often(اکثر)	2. Seldom(کبھی کبھار)	3. Never(کبھی نہیں)

20 House structure is pre-earthquake(2005) ? (آپ کا گھر 2005 کے زلزلے سے پہلے تعمیر شدہ ہے)	1.Yes (ہاں)	2. No (نہیں)

21 Do you have experienced earthquake in past? (کیا ماضی میں زلزلے کا سامنا کرچکے ہیں؟)	1.Yes (ہاں)	2. No (نہیں)
22 Do you think there will break down of supplies after earthquake? (کیا آپ سمجھتے ہیں کہ زلزلے کے بعد ترسیلات رک جائیں گی؟)	1.Yes (ہاں)	2. No (نہیں)
23 Do you know you live in high seismic region? (کیا آپ جانتے ہیں آپ زلزلے کے اعتبار سے خطرناک زون میں رہتے ہیں؟)	1.Yes (ہاں)	2. No (نہیں)
24 Your house has ability to withstand future earthquakes? (کیا آپ کا گھرزلزے کو سہنے کی صلاحیت رکھتا ہے؟)	1.Yes (ہاں)	2. No (نہیں)
25 Do you have information about precautionary measures? (کیا آپ احتیاطی تدابیر کے بارے میں جانتے ہیں؟)	1.Yes (ہاں)	2. No (نہیں)
26 Do you know about emergency plans and protocols? (کیا آپ ہنگامی صورتِ حال کے طریقہ کار اور اصولوں سے واقفیت رکھتے ہیں؟)	1.Yes (ہاں)	2. No (نہیں)
27 Do you have attended First aid training ever? (کیا آپ نے کبھی ابتدائی طبعی امداد کی ٹریننگ حاصل کی ہے؟)	1.Yes (ہاں)	2. No (نہیں)
28 Do you have trust in disaster management authorities & their policies? (کیا آپ ڈیزاسٹرمینیجمنٹ اتھارٹیز اور ان کی پالیسیوں پر اعتماد کرتے ہیں؟)	1.Yes (ہاں)	2. No (نہیں)
29 Do you have trust in information sources like digital & print media? (کیا آپ معلومات کے ذرائع جیسے ٹی وی اور اخبارات کی معلومات پر یقین رکھتے ہیں؟)	1.Yes (ہاں)	2. No (نہیں)
30 Do you believe emergency plans and protocols? (کیا آپ ہنگامی صورتِ حال کے طریقہ کار اور اصولوں کو سود مند سمجھتے ہیں؟)	1.Yes (ہاں)	2. No (نہیں)
31 Do you believe that following building codes can reduce the risk? (کیا آپ سمجھتے ہیں کہ تعمیرات کے قوانین کی پابندی کرکے زلزلے کے خطرات کو کم کیا جاسکتا ہے؟)	1.Yes (ہاں)	2. No (نہیں)
32 In case of any threat, are you willing to follow an evacuation/ migration orders by authorities? (کسی ہنگامی صورت میں آپ علاقہ چھوڑنے کے لیے تیار ہوں گے؟)	1.Yes (ہاں)	2. No (نہیں)

33 Do you believe that earthquake effects can be minimized? (کیا آپ سمجھتے ہیں کہ زلزلے کے اثرات / نقصانات کو کم کیا جاسکتا ہے؟)	1.Yes (ہاں)	2. No (نہیں)
34 Do you believe that natural hazards are fatalistic? Or can be avoided? (کیا قدرتی آفات مہلک ہوتی ہیں یا ان سے بچا جاسکتا ہے؟)	1.Yes (ہاں)	2. No (نہیں)
35 Do you think conventional construction should be allowed in high seismic risk zone? (کیا آپ سمجھتے ہیں کہ زلزلے کے لحاظ سے زیادہ خطرناک علاقوں میں عام طریقے سے تعمیرات کی جانی چاہیے؟)	1.Yes (ہاں)	2. No (نہیں)
36 Mentally prepared for stressful situations? (پریشان کن صورتِ حال کا سامنا کرنے کے لیے تیار ہیں؟)	1.Yes (ہاں)	2. No (نہیں)
37 Able to calm down yourself and others? (خود کو اور دوسروں کو حوصلہ دینے کے قابل ہیں؟)	1.Yes (ہاں)	2. No (نہیں)
38 Emergency contact Nos present in phone? (فون میں ہنگامی صورتِ حال میں کسی مددگار کا نمبر موجودہے؟)	1.Yes (ہاں)	2. No (نہیں)
39 Able to monitor news during disaster? (آفات کے دوران خبروں سے جُڑے رہ سکتے ہیں؟)	1.Yes (ہاں)	2. No (نہیں)
40 Structural design performed? (گھر کی تعمیر سے قبل انجینئر سے مکمل ڈیزائن کروایا گیا؟)	1.Yes (ہاں)	2. No (نہیں)
41 Secured high furniture? (اونچے قد کے فرنیچر کو گرنے سے محفوظ کرلیا ہے؟)	1.Yes (ہاں)	2. No (نہیں)
42 Retrofitting of building? (عمارت کی ریٹروفٹنگ/بحالی کروائی جاچکی ہے؟	1.Yes (ہاں)	2. No (نہیں)
43 Non-structural parts secured? (عمارت کے ثانوی اجزاء جیسے حفاظتی دیوار، سیڑھی وغیرہ گرنے سے محفوظ ہیں؟)	1.Yes (ہاں)	2. No (نہیں)
44 Regular maintenance (باقاعدہ مرمت کی جاتی ہے؟)	1.Yes (ہاں)	2. No (نہیں)
45 Alternate house in non-seismic zone? (زلزلے سے محفوظ علاقے میں متبادل مکان موجود ہے؟)	1.Yes (ہاں)	2. No (نہیں)
46 Alternate sources of income that can’t be disturbed by earthquake? (کوئی ایسا ذریعہِ آمدن خو زلزلے سے متاثر نہ ہو؟)	1.Yes (ہاں)	2. No (نہیں)

47 Asset other than house? (گھر کے علاوہ کوئی اثاثہ؟)	1.Yes (ہاں)	2. No (نہیں)
48 Can get loan from banks for rebuilding house? (بینک سے تعمیرِ نو کے لیے قرض لینے کے قابل ہیں؟)	1.Yes (ہاں)	2. No (نہیں)
49 Family or friends will support for rebuilding? (خاندان والے یا دوست احباب گھر کی تعمیرِ نو میں مدد کریں گے؟)	1.Yes (ہاں)	2. No (نہیں)
50 First aid kit? (ابتدائی طبعی امداد کا سامان موجود ہے؟)	1.Yes (ہاں)	2. No (نہیں)
51 Fire extinguisher? (آگ بجھانے کا آلہ موجود ہے؟)	1.Yes (ہاں)	2. No (نہیں)
52 Earthquake training drills performed? (زلزلہ میں جسمانی تحفظ کی مشقیں سیکھ لی ہیں؟)	1.Yes (ہاں)	2. No (نہیں)
53 Tent available? (ٹینٹ موجود ہے؟)	1.Yes (ہاں)	2. No (نہیں)

Appendix B Physical vulnerability data collection form

Survey form "Annex B" for estimating physical vulnerability of buildings.					
S.No	Ground Terrain	Slope	No slope		
1.	Soil type	Soft soil	Stiff soil	Dense soil & soft rock	Hard rock
2.	Material quality	Poor	Average	Excellent	
3.	Masonry material	Stone	Bricks	Hollow blocks	
4.	Type of structure	Load bearing (Unconfined)	Load bearing (Confined)	RC frame with infill walls	Confined masonry with corrugated sheet roof
5.	Building design & supervision	Intuitive based design by client	Local contractor	Professional/Govt. authorities.	
6.	Height & No of stories	Greater than 3	3	2	1
7.	Apparent construction quality	Poor	Moderate	Excellent	
8.	Building age(years)	Above 30	21-30	11-20	Less than 10
9.	Cracking	Structural	Non structural	No cracking	
10.	Maintenance of building	Not done	Done		
11.	Short columns	Present	Absent		
12.	Floating & hanging columns	Yes	No		
13.	Soft story (Due to masonry infill)	Yes	No		
14.	Soft story (Due to relatively large columns)	Yes	No		
15.	Alterations(Adding stories or increasing floors)	Yes	No		
16.	Heavy mass at top (Water tank etc)	Yes	No		
17.	Out of plane set back	Yes	No		
18.	Plan configuration	Irregular	Regular		

19.	Substantial overhangs (greater than 1.5m)	Yes	No		
20.	Re-entrant corners	Yes	No		
21.	Diaphragm openings	>50% of diaphragm width	<50% of diaphragm width	No diaphragm Opening	
22.	Distance b/w adjacent buildings	<4% of small bldg. height	>4% of small bldg. height	Zero distance (Attached buildings)	
23.	Existence of more than 2 bays	No	Yes		
24.	Location of masonry infills	Irregular	Regular		
25.	Parapets anchorage	No anchored	Anchored		
26.	Inadequately supported sun shades or canopies	Yes	No		
27.	Heavy claddings	Yes	No		

Appendix C FEMA Visual Screening form

Rapid Visual Screening of Buildings for Potential Seismic Hazards
FEMA P-154 Data Collection Form

Level 1
VERY HIGH Seismicity

PHOTOGRAPH

Address: ______
Zip: ______
Other Identifiers: ______
Building Name: ______
Use: ______
Latitude: ______ **Longitude:** ______
S_S: ______ S_1: ______
Screener(s): ______ **Date/Time:** ______

No. Stories: Above Grade: ____ Below Grade: ____ **Year Built:** ____ ☐ EST
Total Floor Area (sq. ft.): ______ **Code Year:** ______
Additions: ☐ None ☐ Yes, Year(s) Built: ______

Occupancy: Assembly / Commercial / Emer. Services / ☐ Historic / ☐ Shelter
Industrial / Office / School / ☐ Government
Utility / Warehouse / Residential, # Units: ______

Soil Type: ☐ A Hard Rock ☐ B Avg Rock ☐ C Dense Soil ☐ D Stiff Soil ☐ E Soft Soil ☐ F Poor Soil DNK If DNK, assume Type D.

Geologic Hazards: Liquefaction: Yes/No/DNK Landslide: Yes/No/DNK Surf. Rupt.: Yes/No/DNK

Adjacency: ☐ Pounding ☐ Falling Hazards from Taller Adjacent Building

Irregularities: ☐ Vertical (type/severity) ______
☐ Plan (type) ______

Exterior Falling Hazards: ☐ Unbraced Chimneys ☐ Heavy Cladding or Heavy Veneer
☐ Parapets ☐ Appendages
☐ Other: ______

COMMENTS:

SKETCH

☐ Additional sketches or comments on separate page

BASIC SCORE, MODIFIERS, AND FINAL LEVEL 1 SCORE, S_{L1}

FEMA BUILDING TYPE — Do Not Know	W1	W1A	W2	S1 (MRF)	S2 (BR)	S3 (LM)	S4 (RC SW)	S5 (URM INF)	C1 (MRF)	C2 (SW)	C3 (URM INF)	PC1 (TU)	PC2	RM1 (FD)	RM2 (RD)	URM	MH
Basic Score	2.1	1.9	1.8	1.5	1.4	1.6	1.4	1.2	1.0	1.2	0.9	1.1	1.0	1.1	1.1	0.9	1.1
Severe Vertical Irregularity, V_{L1}	-0.9	-0.9	-0.9	-0.8	-0.7	-0.8	-0.7	-0.7	-0.7	-0.8	-0.6	-0.7	-0.7	-0.7	-0.7	-0.6	NA
Moderate Vertical Irregularity, V_{L1}	-0.6	-0.5	-0.5	-0.4	-0.4	-0.5	-0.4	-0.3	-0.4	-0.4	-0.3	-0.4	-0.4	-0.4	-0.4	-0.3	NA
Plan Irregularity, P_{L1}	-0.7	-0.7	-0.6	-0.5	-0.5	-0.6	-0.4	-0.4	-0.4	-0.5	-0.3	-0.5	-0.4	-0.4	-0.4	-0.3	NA
Pre-Code	-0.3	-0.3	-0.3	-0.3	-0.2	-0.3	-0.2	-0.1	-0.1	-0.2	0.0	-0.2	-0.1	-0.2	-0.2	0.0	0.0
Post-Benchmark	1.9	1.9	2.0	1.0	1.1	1.1	1.5	NA	1.4	1.7	NA	1.5	1.7	1.6	1.6	NA	0.5
Soil Type A or B	0.5	0.5	0.4	0.3	0.3	0.4	0.3	0.2	0.2	0.3	0.1	0.3	0.2	0.3	0.3	0.1	0.1
Soil Type E (1-3 stories)	0.0	-0.2	-0.4	-0.3	-0.2	-0.2	-0.2	-0.1	-0.1	-0.2	0.0	-0.2	-0.1	-0.2	-0.2	0.0	-0.1
Soil Type E (> 3 stories)	-0.4	-0.4	-0.4	-0.3	-0.3	NA	-0.3	-0.1	-0.1	-0.3	-0.1	NA	-0.1	-0.2	-0.2	0.0	NA
Minimum Score, S_{MIN}	0.7	0.7	0.7	0.5	0.5	0.5	0.5	0.5	0.3	0.3	0.3	0.2	0.2	0.3	0.3	0.2	1.0

FINAL LEVEL 1 SCORE, $S_{L1} \geq S_{MIN}$:

EXTENT OF REVIEW

Exterior: ☐ Partial ☐ All Sides ☐ Aerial
Interior: ☐ None ☐ Visible ☐ Entered
Drawings Reviewed: ☐ Yes ☐ No
Soil Type Source: ______
Geologic Hazards Source: ______
Contact Person: ______

LEVEL 2 SCREENING PERFORMED?

☐ Yes, Final Level 2 Score, S_{L2} ______ ☐ No
Nonstructural hazards? ☐ Yes ☐ No

OTHER HAZARDS

Are There Hazards That Trigger A Detailed Structural Evaluation?

☐ Pounding potential (unless S_{L2} > cut-off, if known)
☐ Falling hazards from taller adjacent building
☐ Geologic hazards or Soil Type F
☐ Significant damage/deterioration to the structural system

ACTION REQUIRED

Detailed Structural Evaluation Required?

☐ Yes, unknown FEMA building type or other building
☐ Yes, score less than cut-off
☐ Yes, other hazards present
☐ No

Detailed Nonstructural Evaluation Recommended? (check one)

☐ Yes, nonstructural hazards identified that should be evaluated
☐ No, nonstructural hazards exist that may require mitigation, but a detailed evaluation is not necessary
☐ No, no nonstructural hazards identified ☐ DNK

Where information cannot be verified, screener shall note the following: EST = Estimated or unreliable data OR DNK = Do Not Know

Legend: MRF = Moment-resisting frame; BR = Braced frame; RC = Reinforced concrete; SW = Shear wall; URM INF = Unreinforced masonry infill; TU = Tilt up; MH = Manufactured Housing; LM = Light metal; FD = Flexible diaphragm; RD = Rigid diaphragm