EARTHQUAKE EMERGENCY PREPAREDNESS AND RESPONSE – A CASE STUDY OF THECHO VDC LALITPUR

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Submitted to the Central Department of Geography

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In Partial Fulfillment of the Requirements for **MASTER'S DEGREE**

In

GEOGRAPHY

By

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LETTER OF RECOMMENDATION

This is to certify that the thesis submitted by Miss Sony Maharjan, " Earthquake Emergency Preparedness and Response - A Case Study of Thecho VDC.", has been prepared under my supervision in partial fulfillment of requirement for the Degree of Master of Social Science in Geography. I recommend this thesis to the evaluation committee for examination.

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APPROVAL LETTER

The present thesis submitted by Ms. Sony Maharjan entitled as "Earthquake Emergency Preparedness and Response - A Case Study of Thecho VDC" has been accepted in partial fulfilment of the requirements for Master's Degree of the Faculty of Humanities and Social Science in Geography.

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ABSTRACT

Natural disaster cannot be stopped but its effect can be minimized or avoided by science, technology and necessary human adjustment i.e. emergency preparedness. Earthquake is one natural event which gives severe threat due to the irregular time intervals between events and lack of adequate forecasting due to its extreme speed of onset. Emergency preparedness is aimed at minimizing the loss of life and property during a natural event. Preparedness includes actions taken in anticipation of the event and special activities both during and immediately after the event. The current study is an attempt to explore emergency preparedness and response to earthquake in Thecho VDC of Kathmandu valley. The main objective of this study is to assess emergency response to earthquake hazard with respect to physical infrastructure condition and human perception. The study also tried to explore level of knowledge, awareness and preparedness of the local people. The research has adopted field observation, Key Informant Survey, household survey using random purposive sampling for the estimation of potential loss of buildings; lifelines, causalities. The RADIUS method has been applied for estimation of probable building damage and casualties in different earthquake scenario. Earthquake risk assessment was conducted based on earthquake shake scenario at two nearest fault lines to Thecho VDC and Gorkha Earthquake fault line. Post earthquake building damage was also assessed caused by 25th April 2015. The survey found that VDC is vulnerable due to the weak structure of buildings and construction materials and method. Spatial location of building damaged caused by 25th April 2015 is coincide with hypothetically earthquake scenarios. It seems that RADIUS method and tool is reliable and valid for the building damage estimation caused by the earthquake. People awareness and preparedness on earthquake was found very less. From the analysis it was concluded that the respondent have a low level of awareness and capacity. The low level of capacity was because of low level of preparedness and awareness. Therefore the study has recommended increasing the efforts in rising effective awareness addressing each sector of the local communities. Awareness and preparedness program should be launched in the VDC by concerned institution and the VDC itself and also need to adopt Earthquake emergency response plan at community level.

Key Words: Earthquake, Building Vulnerability Assessment, RADIUS, Emergency Response and Preparedness Plan

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LIST OF ABBREVIATION AND ACRONYMS

BCDP	Building Code Development Project
DMG	Department of Mines and Geology
DOS	Department of Survey
DPRP	Disaster Preparedness and Response Plan
DRM	Disaster Risk Management
FEMA	Federal Emergency Management Agency
GSHAP	Global Seismic Hazard Assessment Project
HAZUS	Hazard United State
HFF	Himalayan Frontal Fault
HTH	Higher Tibetan Himalayan
IDNDR	International Decade for National Disaster Reduction
ISC	International Seismological Centre
LH	Lesser Himalaya
MBT	Main Boundary Thrust
MDR	Mean Damage Ratio
MMI	Modified Mercalli Intensity
NRA	National Reconstruction Authority
NSDRM	National Strategy for Disaster Risk Management
NSET	National Society for Earthquake Technology-Nepal
PDNA	Post Disaster Need Assessment
PESH	Potential Earth Science Hazard
PGA	Peak Ground Acceleration

PGD	Permanent Ground Displacement
RADIUS	Risk Assessment Tools for Diagnosis of Urban Areas against Seismic Disaster
RCC	Reinforce Cement Concrete
SHSS	Shree Saraswoti High Secondary School
UNDP	United National Development Program
USGS	United States Geological Survey

CHAPTER 1

INTRODUCTION

1.1 Background

Nepal is a Himalayan Kingdom is roughly rectangular (Karanth, 2002) and it is a mountainous country, located in central part of the Himalayan belt. It is situated between the latitudes of 26°22'to 30°27'north and the longitudes of 80°04'to 88°00'12''east. It covers a landmass area of 1, 47,181 sq. km. It spreads 145 to 241 kilometers from north to south and 885 kilometers from east to west. It is located in South Asia occupied only 0.01 percent of the total landmass of the Earth. The country borders to north by People's Republic of China and to the south, east, and west by the Republic of India.

Nepal is characterized by rugged topography, variable climatic conditions, complex geological structure with active tectonic process and continued seismic activities (Karanth, 2002; NSET-Nepal, 2012). The elevation of the country rises from 70 m. in Terai to 8848 m. Such a sharp vertical landscape renders the country highly vulnerable to potential water induced disasters like landslide, slope failure, soil erosion and debris flow. Nepal is divided in three geographical regions- Himalayan, Mountain Hill and Plain Terai, in terms of topography from north to south. The Himalayan region covers 15%, Mountain Hills 68% and the plain Terai 17% of the total area.

A wide variety of physiographic, geological, ecological and metrological factors contribute to the high level of hazards in Nepal. In addition, low level of awareness and demographic factors such as unplanned settlement, improper land use contribute and rapid population growth to increase the vulnerability of the communities. Emergency preparedness is one of the approaches to reduce or avoid effect of natural disaster. It aimed at minimizing the loss of life and property during a natural disaster. Preparedness includes actions taken in anticipation of the event and special activities both during and immediately after the event.

Flood, landslide, earthquake, fire, epidemic, drought and hailstorm are major types of hazard in Nepal. Out of them flood, landslide, and fire are common that occur almost every year with heavy loss of lives and properties (DPNet, 2005). Nepal also lies on the seismic prone area of the world, as it is located along the active faults between tectonic plates (converging plates) along the Himalayas. The entire terrain of Nepal lies in high seismic hazard zone. Earthquake is one of the most destructive natural hazards, which may occur at any time anywhere without warning. So earthquake as sudden ground motion or series of motion can originate in a limited region of the earth and spread from this point in all directions (Jimee, 2006).The most common cause of the release of energy of the vibrations is the breaking and shifting of rocks in crusted. This breaking and movement of rocks is a process known as faulting. Thus, the immediate cause of most earthquakes is faulting.

Four main properties characterizing disasters were identified as: (a) events that are identified in space and time (date, frequency and duration) (b) that have impacts, (c) on social units, (d) which in return come up with responses or adjustments to those impacts (Fritz, Charles, 1996). He has identified the connections between the event, the impacts and the responses to those impacts. The social unit is however, variable in scale as it encompasses individuals, families, groups, institutions or the entire society (Charles & Fritz, 1961).

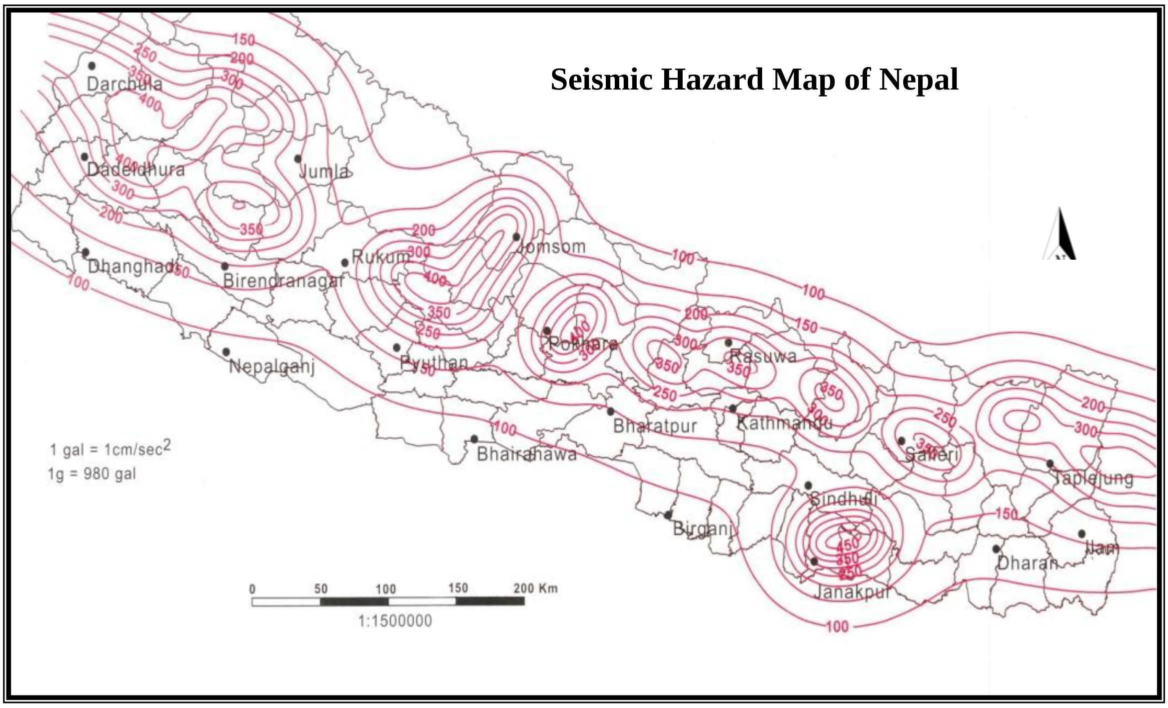
It is observed that the occurrence of earthquake have relationship with the fault boundaries that reveals along the plate boundaries of the earth surface, 92 active have been faults (Karanth, 2002). Nepal was ranked 23rd in the world in terms of total natural hazard related to death and 11th in the world in terms of vulnerability to earthquakes (UNDP/ERRRP, 2009). The World Bank called Nepal, a “hot spots” regarding natural disasters and the Global earthquake initiatives have named Nepal’s capital, Kathmandu, as one of the most vulnerable city in the world to earthquake.

Earthquakes are natural phenomenon that can’t be avoided or even accurately predicted. History shows that the Nepal has experienced a number of major/minor earthquakes even during the last century and thousands of people have lost their lives during these earthquakes. Earthquake is one of the most destructive natural hazards which may occur at any time anywhere without warning that destroys building and infrastructure killing or injuring the inhabitants. Earthquake is a trembling, shaking or vibration of the ground surface caused by the passage of energy, in the form of waves, through the rocks of earth’s outer shell. Earthquake is a unique natural hazard because of its unpredictable nature (Rai, 2010). Ancient Greek believed that strong atlas used to put earth in shoulder. When he felt tired, he put it in another side of shoulder. At that time earthquake occurs. Likewise Hindu people believed that the earth is kept in *Sesnagh* (snake having 5 heads).

Earth shakes in the condition when the snake tries to refresh. But in reality and scientific view it is cause of tectonic movement and volcano eruption. In this way earthquake occurs (Sharma, 2009). An earthquake is a major demonstration of the power of the tectonic forces caused by endogentic thermal conditions of the interior of the earth

Earthquake is a sudden ground motion or series of motion that can originate in a limited region of the earth and spread from this point in all directions (Davis and Gupta, 1990; Gupta and Singh, 1990 as cited in Jimee 2006). So it is one of the most terrible natural phenomena, which depends upon various factors like denudation and tectonic movements caused by endogenetic thermal condition of the interior of the earth.

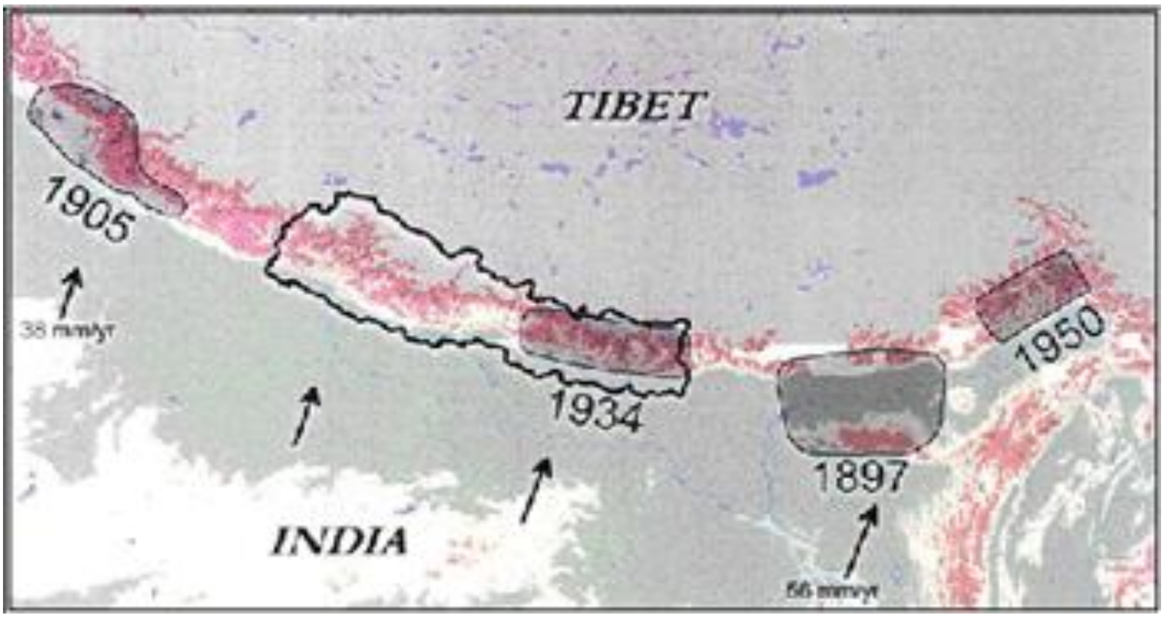
The map shows the bedrock peak ground acceleration contours line in 1gal. The closest contours line indicates the high seismicity zone of the country. Nepal is likely to experience devastating earthquake any time in future (DoMG, 2006).



Source: Department of Source: Mines and Geology, 2002

Figure 1. Seismic Hazard Map of Nepal.

National Seismological Center of Nepal has recorded large earthquakes in the Himalayas like The Kangra- India earthquake of 1905, the Bihar-Nepal earthquake of 1934, and the Assam-India earthquake of 1950; those were all about 8.5 magnitude earthquakes, the biggest intercontinental earthquakes of the country. The geographical profiling of these events show that bigger quakes haven't occurred in western or Central Nepal for the last 200 years (Between the Kathmandu and Deharadun) and that could be potential area for a big earthquake in future (DoMG, 2006). The below figure shows the four major Himalayan earthquakes occurred during different time period.



Source: www.bytesforall.org

Figure 2. Geographical Repartition of the Last Big Himalayan Earthquakes

Nepal has experienced a number of great earthquakes, the most dreadful being the one in the year 1934 A.D., which were 8.4 magnitudes Richter scale. The number of death toll was estimated about around 17,000 and more than 300,000 houses destroyed. Nepal has also suffered many other numbers of destructive events caused by earthquakes.

The 1980 earthquake with epicenter in Bajhang district destroyed more than 2500 houses. Another major earthquake 1988 had its epicenter in Udayapur and measured 6.6 Richter scale and killed more than 7,000 injured more 6,000 around 22,000 houses total collapse. In the time period 1971 to 2003, about 34,000 buildings were destroyed and 56000 were damaged by earthquake. More than 126 million dollar was lost during this period (NSET, 2004).

Earthquake does not kill people but human made structures do (Shah, 2003). The vulnerability of the population depends on damage state of buildings. Therefore, it cannot estimate until the damage buildings.

This is because most of the deaths from earthquakes are caused by buildings or other human construction falling down during an earthquake and always could not be possible to avoid, as in the case of long tunnels and other lifeline structure. Thus, a loss from earthquake hazard mainly depends on (Nelson, 2002): Population density, Construction standards, and Emergency preparedness.

Alternatively, adequate flexibility to absorb the displacement (or self-healing material as in earth and rock filled dams) should be adopted (Arya & Srivastava, 1998). Nepal faces different types of recurrent disasters, such as environmental degradation, deforestation, soil erosion, landslides and floods Disaster’s risks arise when hazards interact with physical, social, economic and environmental vulnerabilities (ISDR, 2003), not only people’s death and big economic loss but also it causes the mental and physical paralysis (Hada, 2007).

Gilbert White (1945) has challenged the notion that natural hazards are best addressed by only engineering solutions and argued that the havoc produced by natural disasters may be better avoided by modifying human behavior and adjustment to reduce potential harm. Emergency response plan is one of such adjustment (White, 1945).

Emergency response plan is detailed program of action to control and or minimize the recurring prompt correctives measures beyond procedures to protect human life, minimize injury, optimize loss control and reduce the exposure of physical assets and the environment (Karanth, 2002). It is the process by which the response to an extraordinary event is categorized into functional components and responsibility for each component is assigned to the appropriate individual or agency.

In this context, this study was carried out to evaluate the earthquake emergency response plan (EERP) which was long term EERP and short term EERP. Its vision is found out EERP when earthquake occurred. It gives the way to reduce the vulnerability in the findings of this study as well as provides the strategies to manage with earthquake disaster in the study area.

In this context, this current study is an attempt to explore emergency response of people at local level (VDC level) before / during / after earthquake incidence. It is also an attempt to explore relationship between building structure and vulnerability to earthquake.

1.2 Statement of problem

Emergencies and disasters can occur any time without warning. The more prepared for them, the better will be able to act, minimizing panic and confusion when and emergency occurs. (Emergency Resopose Guide, 2014). Nepal is one of the most disaster prone countries in the world. It is affected by various types of natural disasters each year. The Global earthquake initiative has named Nepal’s capital, Kathmandu as one of the most vulnerable cities in the world to earthquake.

In Kathmandu valley, a frightening estimate would count approximately 40,000 deaths and 95,000 injured. More than 60% of the existing buildings would be destroyed, many beyond repair, leaving 600,000 to 900,000 residents homeless (NSET, 2004).

Earthquake hazard is beyond human control however, loss and damage can be reduced by human effort, which is possible only when people are aware. The most important requirement for the reduction of human, economic, physical and mental losses and damages is the human awareness and consciousness.

Hazard are natural phenomena hence its occurrence is unpredictable and uncontrolled. In the same way loss cause by them are also obvious but if people are not aware and conscious about them then there would be possibility of further losses. And if they are aware, they would be conscious for emergency response which would support to deduct the possible losses and to recover and overcome such losses caused by hazards.

In case of the study area, awareness and preparedness on emergency in the time of disaster seems low. For these all reasons, there is necessity for the study of emergency response plan because timely study planning and proper research could decrease losses. So, it's necessary to know how people used to do emergency responses before and in recent times, what their activities for emergency response are and who are capable and ready for handling the responsibilities for emergency response plan. In this way emergence, response plan is necessary for management and protection of this area.

1.3 Objectives of Research

General Objective

General objective of this study is to access emergency response in earthquake hazard.

Objectives of study

a) To analyze socio-economic losses due to historical earthquake hazards.
b) To assess the potential risk of earthquake in terms of building structure.
c) To investigate emergency response planning/Strategy in earthquake hazard

1.4 Significance of the study

Earthquake is perhaps the disaster by which human beings were suffering from past time. Till now, people are not successful to have proper solution for it. There were some prediction of earthquake but they were not successful and precise. So, unpredictable earthquake may occur at any time, at any place.

If the Earthquake similar to 1990 occurs in study area, it will kill 800 people, injure 3200 people, and destruct 900 houses (Thecho, 2015). According to the same report, Fire is second most destructive disaster in the area. Therefore, it is necessary to be ready to cope with such earthquake at any time in this area also for this we need to have emergency response plan. The study of current community disaster management and responses seems to be urgent for future plan and program. It will help to collect and keep database, support to the policy making and assist to local government, community and other stakeholder to make framework of emergency response plan and implement for better society. Such information will be also very helpful for researcher and planners.

1.5 Limitations

This study will deal with Thecho VDC only which means micro level study that at field research activities has focused on the area.

The research will focus on earthquake hazard only. This does not mean that other hazards are less important. This research would not focus on other hazards because of lack of time and limited resources. Limited time and limited resources play a vital role in research.

The study is going to use qualitative and qualitative approach. Different data obtained in this research will help on policy making and plan will be gathered from the secondary sources. Thus, the data and analysis of my study cannot generalize for forever. It will be only a part of certain time which might help to make plan for future.

Two fault line have taken for earthquak scenario in RADIUS method.

Sample, participant observation, interview, focus group discussion, key informant survey, questionnaire method will be use to get primary data or information.

1.6 Research Questions

a. What types of association exist between historical earthquakes and physical / human damage / loss?
b. What type of settlement pattern and physical structures exist in traditional locality? What is the relation between the settlement and population distribution?
c. How do people perceive, adjust and response to earthquake disaster?

CHAPTER II

REVIEW OF LITERATURE

2.1 Concept of seismic hazard and risk

A disaster is a serious disturbance of the functioning of a society and cause great damage to human being and physical property. Disaster is caused by natural hazards and risks associated with earthquakes are commonly referred to as seismic hazards; some related terms frequently used in the study are given below.

Hazard: Hazard is an event or occurrence that may represent future threats has the potential for causing injury to life or damage to property or the environment and it is physical characteristics that may cause an emergency or potentially damaging physical event, phenomenon, or human activity which may cause loss of life and property damage (Smith, 2001). Hazards can be combined in their origin and effects. Each hazard is characterized by its location, intensity, frequency and probability. Earthquake hazard is usually expressed in probabilities of occurrence of certain earthquake (ground shaking) in a time.

Disaster: A serious disruption of the functioning of a community or a society causing widespread human, material, economic, or environmental losses. Disasters often result in great damage, loss or destruction. Disasters occur when hazards meet vulnerability (Blaikie, Cannon, Davis, & Wisner, 1994). Disasters can be characterized by the scope of an emergency. An emergency becomes a disaster when it exceeds the capability of the local resources to manage it.

Earthquake Hazard: An earthquake is a sudden shift or movement of the earth's crust caused by the release of stress accumulated along geologic faults or volcanic activity (Pandey, 1999)**.** The most powerful earthquakes can destroy even the best built of structures. Most earthquakes occur at fault zones where tectonic plates collide against each other. Earthquakes, also called temblors (OALD, 2007), they occur by the thousands every day around the world, usually in the form of small tremors.

Vulnerability: Vulnerability is a set of conditions and process resulting from physical, social, economical and environmental factors which increase the susceptibility of a community to the impact of hazards, (UNDP, 2004). Positive factors that increase the ability of people and the society they live in to cope effectively with hazards that increase their resilience or reduce their susceptibility are considered as capacities.

Risk: Risk is the probability of harmful consequences or expected loss (Khanal, Shrestha, & Ghimire, 2007). Another definition of Risk is the potential or likelihood of an emergency to occur. Risk results from the interaction between natural/ human induced and vulnerable conditions. For which can be calculated by the equation.

Risk= probability of hazard × vulnerability /capacity

Earthquake Magnitude: The magnitude of earthquake measures the total seismically released energy, so it must also be related to ground acceleration of the area from where the energy is released.

Earthquake Intensity: The effect of earthquake is assessed in terms of intensity. Intensity refers to the severity of ground shaking experienced at site. It is subjective measurement; however it includes all the earthquake variables which are magnitude, hypo-central distance, attenuation media and local enhancing factor. It is generally greatest near the epicenter and decreases outwards from it. Intensity is usually expressed on the Modified Mercalli Intensity scale which ranges from I to XII. Earthquake magnitude and their effect have been given in Table 1**.**

Table 1. Damage and Perception for each Value on the Modified Mercalli Scale of Earthquake Intensity

Intensity (MMI)	**Description of characteristic effect**	**Maximum Acceleration(g)**	**Magnitude (Richter Scale)**
I	Instrumental: detected only by seismometers	0.001	
II	Feeble: notice only by sensitive people	0.0025	
III	Slight: like the vibrations due to a passing truck, felt by people at rest, especially on upper flees.	0.005	3.5 to 4.2
IV	Moderate: felt by people while walking, rocking of loose objects including standing objects.	0.01	4.3 to 4.8
V	Rather strong: felt generally; most sleepers are awakened and bell rings.	0.025	
VI	Strong: trees sway and all suspended objects swing: damage by overturning and falling of loose objects.	0.05	4.9 to 5.4

VII	Very strong: general alarm: wall crakes, plaster falls	0.1	5.5 to 6.1
VIII	Destructive: car drivers seriously disturbed, masonry fissured, chimney falls, poorly constructed building damaged.	0.25	6.2 to 6.9
IX	Ruinous: some house collapse where ground begins to cracks and pipes break open.	0.5	
X	Disastrous: ground cracks badly, many building destroyed and railway lines bent, landslides on steep slopes	0.75	7 to 7.3
XI	Very disastrous: few building remain standing, ridges destroyed, all services(railway, pipes and cables) out of action, great landslide and floods.	1.0	7.4 to 8.1
XII	Catastrophic: total destruction, objects thrown into air, ground rises and falls in waves.		>8.1

Source: (Pandey, 1999)

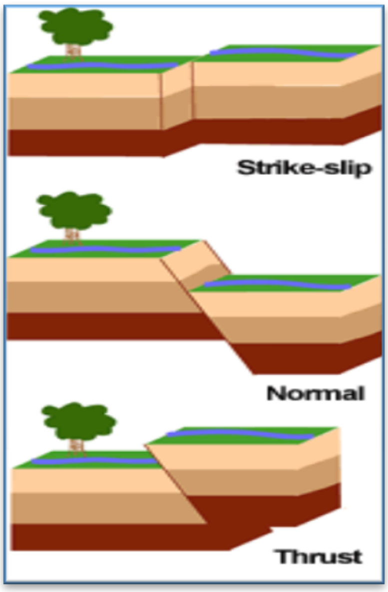
Emergency: An emergency is a serious, dangerous, and unexpected action which deviates from the events that endangers and affects people, property and environment, after which people need to be evacuated and need evacuation site.

Evacuation: An evacuation is to be safe and the people move to a safe area after occurrence of disaster.

2.2 Earthquake and plate boundary relation

Nepal is Located within the Himalayan range, a product of continental collision and subduction between the Indian subcontinent and Eurasia .The continental drift and displacement are considered a reality on the basis of displacement (Singh, 2003). In this process the plate boundaries are divided into three groups: constructive plate boundary, destructive plate boundary and conventional plate boundary.

Himalayas are raised from conventional plate boundary. The two Plate (Ganges plain and Tibetan basement) are constantly moving and its results are, Ganges plain is slide and shallow and Tibetan basement is rising up which are our Himalayas. In every hundred years these two plate move at the rate of two meter (NSET, 2004). These types of movements can do rise up press in under the earth rock. This increase in press will be stopped by earthquake and in Nepal most of earthquake occurs in this way.



Source: (Birtannica, 1994)

Figure 3. Fault Movement

Nepal is located between two major plates, India and Tibetan, the country falls under the seismically very active zone. Nepal is one of the highly risked countries in the world, and ranked as 11th most at risk countries in the world (UNDP/BCPR, 2004). The seismic risk of Kathmandu valley is at the highest in the world (NSET, 2004).

The point on a fault at which the first movement or break occurs during an earthquake is called the earthquake's focus or hypocenter. The point on the earth's surface directly above the focus is the epicenter. Two types of Seismic Waves are Body Waves and Surface Waves (Abbutt, 1987). Body waves are the fastest and are referred to as either Primary or Secondary waves. Primary waves or P wave is the faster and it moves in a push-pull fashion of alternation pulses of compression (push) and extension (pull). Secondary waves or S wave is the second wave which, travel transverse that propagates by shearing or shaking particles in their path at right angles to the direction. Seismic waves that travel near the Earth's surface are of two main types- Love and Rayleigh wave. Both wave are referred to as L waves (Long waves) because they take longer periods of time to complete one cycle of motion and are the slowest moving. All seismic waves represent means of energy release and transmission, they cause the ground shaking. Magnitude and intensity are two ways of describing the size of an earthquake. The amount of ground shaking (amount of vertical motion) is related to the magnitude of the earthquake (Montgomery etc.). Earthquake magnitude is most often reported using the

Richter magnitude scale, name after geophysicist professor Charles Richter, who developed it.

A magnitude number is assigned to an earthquake on placement or shaking on the basis of the amount of ground displacement or shaking on the basis of the amount of ground displacement.

The Richter scale is a logarithmic one, means that an earthquake of magnitude 4 causes 10 times as much ground movement as one of magnitude 3, one hundred times as much as one of magnitude 2, and so on. The amount of energy released rises even faster with increasing magnitude by about a factor of thirty for each unit of magnitude.

Intensity is a measure of the earthquake's effects on human and on surface features. It is not a unique, precisely defined characteristic. The surface effects produced by an earthquake of given magnitude vary considerably as a function of such factors as local geologic conditions, quality of construction and distance from the epicenter.

A single earthquake can produce effects of different intensity in different place, though it will have only magnitude assigned to it. Intensity is, somewhat a subjective measure in that it is based on direct observation by individuals rather than on instrumental measurements.

The most widely applied intensity scale in the United States is the modified Mercalli Scale, a modern version (Modified Mercalli Intensity Scale). Earthquake intensity scale is a qualitative expression of damage by an event, the widely accepted scale is the Mercalli scale named after an Italian seismologist. It is expressed in a Roman letter extending from I to XII.

Before the main shock of earthquake, there are series of small shock which we may not be felt easily, are known as "Foreshock" whereas after the main shock of earthquake, similar series of earthquake occurs which is known as "Aftershock" (NSET, 2004).

2.3 Trend of Earthquakes Incidence and Damage in Nepal

2.3.1 Historical Incidences

Nepal is a high seismic-risk country. The main source of seismic activity in Nepal is subduction of the Indian plate under the Tibetan plate. The presence of three main fault lines: the Main Central Thrust (MCT) at the foot of the Greater Himalaya joining the midland mountains, the Main Boundary Fault (MBF) at the junction of the Lesser Himalaya and the Siwaliks and the Himalayan Frontal Fault (HFF) south of the Siwaliks, each running east to west, are the main causes of earthquakes of small and great magnitude in Nepal. These fault lines are a result of the movement of the Indian plate under the Eurasian plate. Earthquakes of major consequence were reported in 1255 AD, 1810 AD, 1866 AD, 1934 AD, 1980 AD and 1988 AD in Nepal. In 1934 Bihar-Nepal earthquake with magnitude of 8.4 Richter scale, where in total 8519 people lost their lives in Nepal, a total of 126355 houses were severely damaged and around 80893 buildings were completely destroyed (NSET, 2015).

Nepal experienced three major earthquake: a 6.5 magnitude quake in Bajhang district that killed 178 people and destroyed about 40000 building and a 6.6 magnitude quake in Udayapur district that killed 721 people and destroyed 64,467 building (EMI, 2005). Similarly, in a recent period, a moment magnitude of 6.9 earthquake occurred in eastern part of Nepal near the Nepal-Sikkim boarder on September 18, 2011.

2.3.2 Earthquake of 25 April, 2015 (2072 Baishak 12)

The earthquake occurred on 25 April 2015 at 11:56 am at a depth of approximately 15 km with its epicenter approximately 34 km east southeast of Lamjung, Nepal, lasting approximately twenty second.

The earthquake was initially reported as 7. 8 M by the United States Geological Survey (USGS). Its epicenter was identified at a distance of 80 km to the northwest of Kathmandu, the capital of Nepal. Bharatpur was the nearest major city to the main earthquake, 53 km from the epicenter. The second earthquake was somewhat less powerful at 6.6M. Over thirty- five aftershocks of magnitude 4.5 m or greater occurred in the day following the initial earthquake, including the one of magnitude 6.6 m (DcNepal, 2015).

According to the USGS, the temblor was caused by a sudden thrust, or release of built-up stress, along the major fault line where the Indian plate, carrying India, is slowly diving underneath the Eurasian Plate, carrying much of Europe and Asia. Kathmandu, situated on a block of crust approximately 120km wide and 60 km long, shifted 3 m to the south in just 30 seconds. The earthquake caused many avalanches on Mount Everest and landslides in the Langtang Valley. Authorities have so far recovered 193 bodies, including 22 foreigners from Langtang village, which was swept away by a massive torrent of air, snow and rock triggered by the first of two deadly earthquakes to hit Nepal in April and May (DcNepal, 2015).

Earthquake killed 8019 people and injured people were 17,803 people, thousands of buildings were destroyed, several of the cultural buildings in the Kathmandu valley were destroyed. Most of culture heritage were losses. A UNESCO World Heritage Site, collapsed, as did the Dharahara tower, built in 1832. The collapse of the latter structure killed at least 180 people. Several temples including Kasthamandap, Panchtale temple, the top levels of the nine- storey Basantapur Durbar, the Dasa Avtar temple and two dewals located behind the Shiva Pravati temple were demolished by the quake. Some other monuments, including the Kumari Temple and the Taleju Bhawani Temple partially collapsed.

(a) (b)

Source: (Daileda, 2015)

Figure 4. Great Earthquake 2015 a) before earthquake b) after earthquake 2015

The top of the Jaya Bageshwari Temple in Gaushala and some parts of the Pashupatinathe Temple, Swyambhunath, Boudhanath Stupa, Ratna Mandir inside Rani Pokhari and Durbar High School have been destroyed. Outside the Valley, the Manakamana Temple in Gorkha, the Gorkha Durbar, the Palanchok Bhagawati Kabhrepalanchok District, the

Rani Mahal in Palpa District, the Churiyamai in Makwanpur District, the Dolakha Bhimsensthan in Dolakha District, and the Nuwakot Durbar were partially destroyed.

Table 2.3. Major historical earthquake are summarized

<table>
<tr><th>Year</th><th>Date</th><th>Earthquakes epicenter</th><th>Human deaths</th><th>Human injured</th><th>Building Collapsed</th><th>Building Damaged</th></tr>
<tr><td>1255</td><td>7 Jun</td><td>NA</td><td colspan="2">One third of total population including king Abhya Malla was killed</td><td colspan="2">Many buildings and Temple collapsed</td></tr>
<tr><td>1260</td><td>NA</td><td>NA</td><td>NA</td><td>NA</td><td>NA</td><td>NA</td></tr>
<tr><td>1408</td><td>NA</td><td>NA</td><td colspan="2">Heavy</td><td colspan="2">Heavy</td></tr>
<tr><td>1681</td><td>NA</td><td>NA</td><td>NA</td><td>NA</td><td>NA</td><td>NA</td></tr>
<tr><td>1767</td><td>Jun</td><td>NA</td><td>NA</td><td>NA</td><td>NA</td><td>NA</td></tr>
<tr><td>1810</td><td>May</td><td>NA</td><td colspan="2">Moderate</td><td colspan="2">Heavy</td></tr>
<tr><td>1823</td><td>NA</td><td>NA</td><td>NA</td><td>NA</td><td>NA</td><td>NA</td></tr>
<tr><td></td><td>25 Sep</td><td>NA</td><td>NA</td><td>NA</td><td>NA</td><td>NA</td></tr>
<tr><td>1833</td><td>26 Aug</td><td>NA</td><td>NA</td><td>NA</td><td colspan="2">18000 in Total</td></tr>
<tr><td></td><td>11 Jul</td><td>NA</td><td>NA</td><td>NA</td><td>NA</td><td>NA</td></tr>
<tr><td></td><td>13 Jul</td><td>NA</td><td>NA</td><td>NA</td><td>NA</td><td>NA</td></tr>
<tr><td></td><td>26 Sep</td><td>NA</td><td>NA</td><td>NA</td><td>NA</td><td>NA</td></tr>
<tr><td>1834</td><td>Sep-Oct</td><td>NA</td><td>NA</td><td>NA</td><td>NA</td><td>NA</td></tr>
<tr><td>1837</td><td>17 Jan</td><td>NA</td><td>NA</td><td>NA</td><td>NA</td><td>NA</td></tr>
<tr><td>1934</td><td>15 Jan</td><td>Bihar /Nepal</td><td>8519</td><td>NA</td><td>80893</td><td>126355</td></tr>
<tr><td>1980</td><td>4 Aug</td><td>Bajhang</td><td>46</td><td>236</td><td>12817</td><td>13298</td></tr>
<tr><td>1988</td><td>21 Aug</td><td>Udayapur</td><td>721</td><td>6453</td><td>22328</td><td>49045</td></tr>
<tr><td>1993</td><td>NA</td><td>Jajarkot</td><td>NA</td><td>NA</td><td colspan="2">40 % of Buildings are estimated to be affected</td></tr>
<tr><td>2002</td><td>NA</td><td>Mahottari</td><td>NA</td><td>41</td><td>NA</td><td>NA</td></tr>
<tr><td>2003</td><td>NA</td><td>Syangja</td><td>1</td><td>2</td><td>NA</td><td>NA</td></tr>
<tr><td>2011</td><td>18 Sep</td><td>Taplejung Sikkim Border</td><td>6</td><td>Na</td><td>Na</td><td>Na</td></tr>
<tr><td>2015</td><td>25 April</td><td>Goharka Barpak</td><td>8970</td><td>22900</td><td>Na</td><td>Na</td></tr>
<tr><td colspan="7">Note: "NA" indicates 'description not available'.</td></tr>
</table>

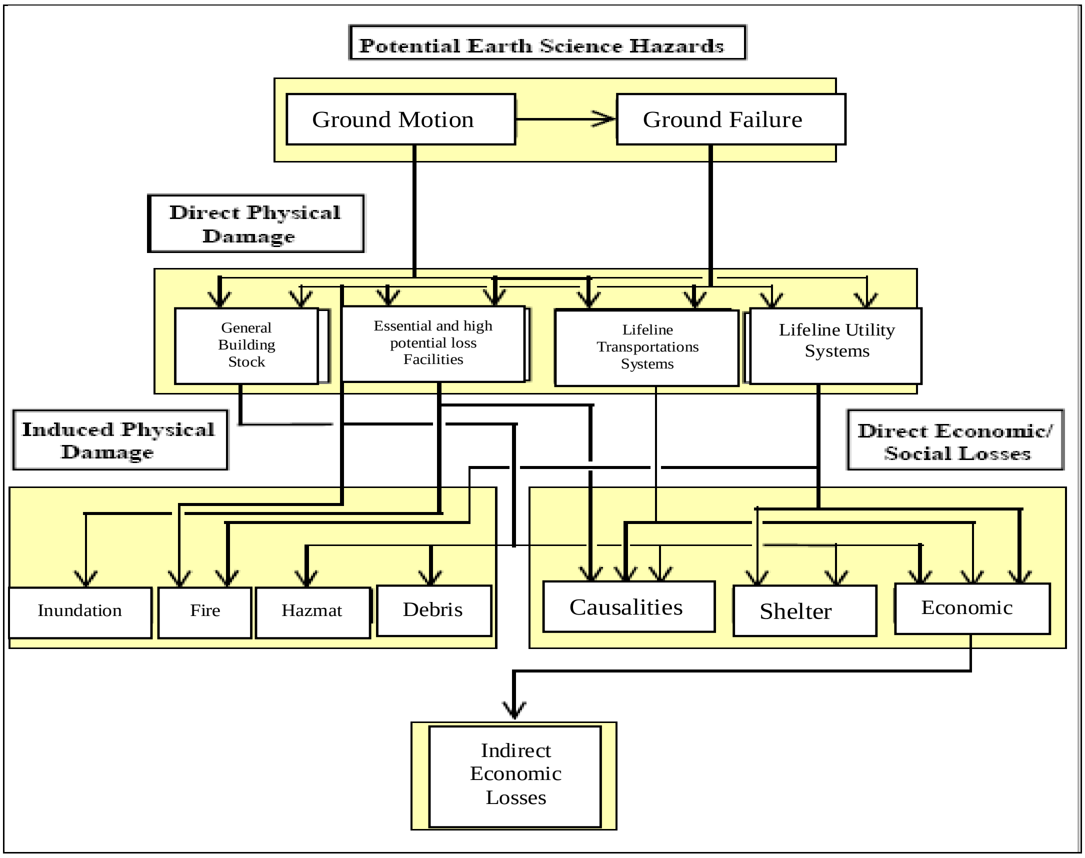
Source: www.nset.org.np 2015 August 24

2.4 Theoretical Models and Concepts in Vulnerability Assessment

HAZUS Method

HAZUS is as part of efforts to mitigate hazards and protect lives and property from the devastating effects of natural disasters. United States Federal Emergency Management Agency developed HAZUS method to provide individual, business, and communities with information and tools to work proactively to mitigate hazards and prevent losses resulting from all disasters. Using GIS technology, HAZUS allows users to compute estimates of damage and losses that could result from an earthquake to support FEMA's mitigation and emergency preparedness efforts. HAZUS is being expanded into HAZUS-MH, a multi hazard methodology with new modules to estimate potential losses from wind and flood hazard. In addition to estimating losses, HAZUS contains a database of economic census, building stock, transportation facilities, local geology and other information that can be used for a number of steps in the risk assessment process.

The overall framework of the HAZUS method



Source: NSET- Nepal cited in Khatiwada 2008

The framework of the method includes each of the components shown in Figure 2.4, which are potential earthquake hazards, direct physical damage, induced physical damage, direct economic/social loss and indirect economic loss. These factors are related with each other. In general, each component will be required for loss estimation. However, the degree of sophistication and associated cost will vary greatly by user and application.

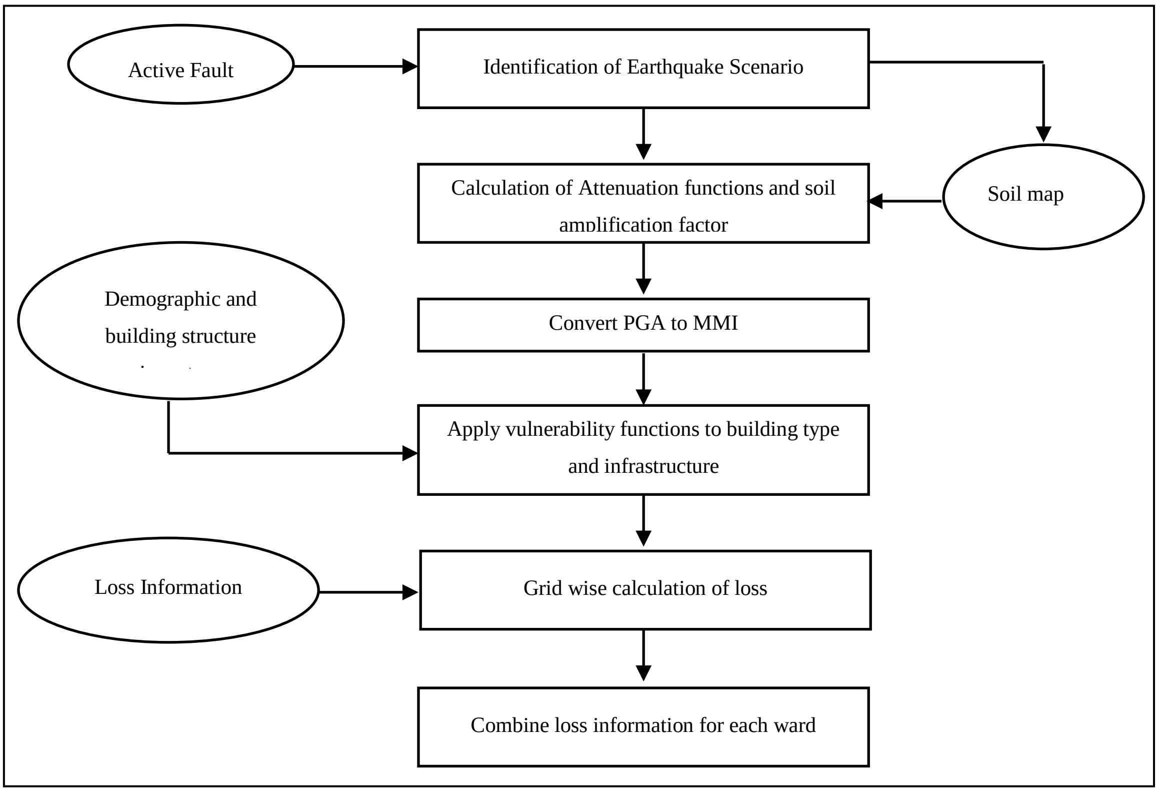
RADIUS Method

Risk Assessment Tools for Diagnosis of Urban Area against Seismic Disasters (RADIUS) is a simple computer tool use to estimate the earthquake damage. It is lunch by the United Nations, as a contribution to the International Decade for Natural Disaster Reduction (INDR 1990-200 cited in Guragain, 2004) aiming to reduce seismic distastes in urban areas. The RADIUS project initiated from 1996 till 1999, with financial and technical assistance from the government of Japan. The RADIUS method is more appropriate to prepare fast earthquake scenarios that better fits in the needs of earthquake-threatened cities in developing countries. Another main objective of this tool is to reduce seismic disaster in urban areas, especially in developing countries.

The estimation of the potential damage of an adopted hypothetical earthquake is carried out in two steps: theoretical and non-theoretical. The theoretical estimation is performed by combining the seismic intensity distribution that is estimated for the adopted earthquake with the inventory of the structures and infrastructure of the city. This combination is performed using vulnerability functions that are developed to reflect the seismic behavior of the structures and infrastructure found in the city (Chaudhari, 2008).

There are various factors in a building itself like: materials used, age of building, number of stories, method of construction etc. which are responsible to cause the damage of the building. So, it is necessary to identify different parameters and use different techniques for measurement of such parameters.

RADIUS Method



Source: Tung cited in Chaudhary 2008

Review of Empirical Studies

The building damage and collapse probability estimated for individual buildings considering building height, construction type and earthquake intensity using a damage matrix found that intensity IX earthquake, 26% of the total building of Lalitpur ward 20 has high probability of collapse (Jimee, 2006). He identified that more casualties are estimated in non-residential building during day time and residential building at night. The study concluded that the level of awareness and preparedness is very poor in study area. Hence the study recommended that to increase the awareness the program at local community level is required.

The population vulnerability of Lalitpur Sub Metropolitan City (LSMC) studied on the basis of building loss estimation. This study was carried out to determine factors of population vulnerability and to develop a method for the estimation of population distribution both in space and time (Islam, 2004). The study has mainly three components, identifying the homogenous units of buildings, estimating the number of casualties in case of an earthquake and estimating the spatial and temporal distribution of population. The distribution of population has been converted to the number of casualties based on the building vulnerability using HAZUS method, the study showed that 16 different spatial distribution of different casualty for number of earthquake scenarios.

Guragain (2004) carried out the seismic building vulnerability assessment in the Lalitpur area. In order to carry out the seismic vulnerability assessment of building directed field observation was carried out. The building losses in the Lalitpur for different probable earthquake scenario were calculated using an existing intensity damage matrix of the area prepared during the preparation of building code and modified by JICA and NSET. Two types of building damages were calculated i.e. partial damage and complete collapse. On his study he found that for each scenario earthquake, a large number were found damage in the core area. He concluded that for the different earthquake scenarios, the total number of damaged building were estimated ranging from 1654 to 22,293 in the worst case scenario, which corresponds to an 8 Magnitude earthquake located close to Kathmandu.

Ghimire (2008) in her study applied RADIUS as an earthquake risk management tool in Panauti municipality. Two scenario earthquakes, namely North Banepa earthquake and 1934 Earthquake were considered to obtain various results for both causalities, building damages and lifeline damages. She concluded that the cause of North Banepa Earthquake, if struck during the night time will result into 1505 injuries and 150 deaths out of total 25563 population where as earthquake 1934 earthquake during night time will result into 31 injuries and 1 deaths. She also concludes that RADIUS tool was successfully employment for Panauti municipality. During its implementation it was found out that RADIUS was an effective tool for earthquake damage estimation that could be used for municipal earthquake risk planning and management.

Khatiwada (2008) studied Seismic Vulnerability of Building: A Case Study of Ilam Municipality. The main objectives of his study were to determine the collapse and damage probability of building under the different probable earthquake scenario. He concluded that most of the buildings have a high probability of damage and collapse by a strong earthquake with an intensity of VIII in the study area. Similarly brick in mud and adobe building area more venerable and it has high probability to damage or collapse. Brick in cemented building (less than 2 floors) have less probability to damage. Building height and geometry are also important parameters of building loss in earthquake period.

Chaudhary (2008) has identified that in Ilam municipality most of the lifeline service built-up without seismic coding. He uses the HAZUS method to estimate the number of damage or probability of certain damage due to earthquake. For the vulnerability study he considered geological hazard, gourd shaking, and landslides to estimate the potential damage by earthquake scenario and found intensity VII and VIII in the different parts of municipality. On his research he identified the lifeline services in Ilam municipality are located on high MMI (Modified Mercally Intensity).

Rai (2009) studied about Spatial Assessment of Seismic Vulnerability in Inaruwa municipality. The main objective of his study was to determine the collapse and damage probability of building under the different probable earthquake scenario. He has conducted research household survey, observation and key informant survey to generate preliminary data as well as GIS and RADIUS tools. RADIUS method is found to be effective and easy in estimating building damage as well as human death and injury. The research concluded that earthquake hazard has direct relation with poverty. Because of poor economy, people are bounded in vulnerable area. In market area economically well don’t give person priority to rebuild new buildings.

Sonar (2009) study on Seismic Vulnerability Assessment in Siddharthanager Municipality his major objectives are to nature and types of building, building damage probability and human causality under different probable earthquake scenario, and awareness and preparedness. He used GIS and RADIUS tool in his research. In his research, he collected the building information of 2743 both residential and non residential household. He further analysis and estimation the level of building damage in the mid Gulmi earthquake scenario, south Palpa earthquake scenario and east Parasi earthquake scenario. He describes about awareness and preparedness on earthquake and find out most of the people are not conscious on earthquake in the Siddharrthanager municipality.

Rai (2010) made a study entitled “Seismic Risk Assessment of Triyuga Municipality”. The major objective was nature, type, collapse, damage probable scenarios earthquake and find out the existing capacity (Knowledge, awareness and preparedness) of the local people. He used RADIUS method for developing earthquake damage scenario of Triyuga Municipality. He has described about different buildings characteristics such as building type, height, geometry, age and attachment etc. Further he explains about North Udayapur earthquake scenario, south Udayapur earthquake scenario, north-east Udayapur earthquake scenario and estimation of the building damage and population casualties.

Sonar's (2009) study examined building damage probability and human causality under different probable earthquake scenario, and awareness and preparedness. He used GIS and RADIUS tool in his research. He analyzed and estimated the level of building damage in the mid Gulmi earthquake scenario, south Palpa earthquake scenario and of building damage in the mid Gulmi earthquake scenario. He discussed awareness and preparedness on earthquake and find out most of the people are not conscious on earthquake in the Siddharrthanagar municipality.

Rai (2010) made a study to explain nature and type of collapse and damage, probable scenarios of earthquake and find out the existing capacity (knowledge, awareness and preparedness) of the local people. He used RADIUS method for developing earthquake damage scenario of Triyuga Municipality. He has described about different building characteristics such as building type, height, geometry, age and attachment etc. Further he explained about North Udayapur earthquake scenario and estimation of the building damage and population casualties.

Shrestha (2009) estimated the buildings damage and casualties that may occur in different probable earthquakes, assessed the knowledge and awareness of the local people about the causes of losses and damage from earthquakes and suggested measures to reduce losses from earthquake. He applies GIS and RADIUS method to analyze data for that study. He explained building damage estimation and casualties in north-east Jhapa earthquake scenario, west Ilam earthquake scenario and north-west Jhapa earthquake scenario. Among three earthquake scenario, different number of buildings damage and casualties resulted because they have different types parameter like as magnitude, distance, direction, fault line etc.

Khanal (2007) made a study entitled Seismic vulnerability assessment of Mechinagar municipality. His major objectives are to identify the level of vulnerability of building, to evaluate the probable damage of the structures and other services and to estimate human causalities by diurnal temporal variation in earthquake occurrence. This research focuses on the possible scenario after a major earthquake strikes Mechinagar municipality and findings of this study are the highest number of destruction of physical structure seems to be effected in ward no. 1 and relatively less in 10. But the effect seems low in ward no. 9.

Similarly the death of people and injury also seems high in ward no.1 and 10 but the rate seems least in 9. The lifeline situation of the municipality also seems in three earthquake scenario. The highest effect of destruction is seemed an electrical and telecommunication substation (22.7%) and least in water and sewage tank and distribution lines (2.6%).

National Disaster Response Plan deals with details information of building culture prevention. It explains about methodology, approach, quick response, and emergency support function and disaster specific modules. It highest quick response, precise actions procedures and responsibilities have to be laid down well in advance in order to ensure timely response in case of any disaster. A mechanism that takes into accounts multiple hazards and basic preparedness has to be articulated in the form of quick response teams, quick assessment team, reporting procedures, checklist and handbook. The mechanism also lays down crucial parameters, requirements and organizational composition of emergency operations center and incident command systems. It also describes disaster specific modules related with earthquake and other disaster such as floods and drainages management, cyclones, tornadoes, hurricanes, cloudburst, Sea erosion etc.

UNESCO's Nepal (2011) discusses the assessment and mitigation of earthquake risk, earthquake prediction, induced seismicity, implication of earthquake, engineering measures for loss reduction with buildings codes, materials and design. In chapter seven explain about the rapid increase of the world's population with its industrialization and technical progress has stimulated a rapid development of construction of all kinds. While in the past buildings were mainly of masonry and wood, new structural systems, materials and techniques are now being used, including prefabricated construction, pre-stressed reinforced concrete, metal structures, synthetic materials, etc. The increased urban population and the use of new construction systems whose resistance to earthquake has not been sufficiently studied has led to an increase of the earthquake hazard and calls for an improvement in the methods for the design of earthquake resistant structure.

Reviewing literatures, it is concluded that earthquake is one of the most destructive hazards, which cause damage and loses of both human and properties. Most of this research is carried out on seismic vulnerability of different region of the country, so the above research is more relevant for this research.

2.5 Policies and Strategies for natural Disaster Risk Management

National Strategy for Disaster Risk Management (NSDRM) 2009

The NSDRM, strategy has been developed according to Hyogo Framework for Action (HFA) 2005 was promulgated in 2009. While preparing NSDRM, 2009 detail process was used. The opinion of governmental, nongovernmental agencies, local bodies, academic institutions, private sector, UN agencies, INGOs and civil society organizations were formed with help of different occasions.

The goal of this strategy is to implement the concept for preparedness on mitigation disaster risk reduction and incidence of calamities. Not only this but also to guide and make sure about effective disaster management which is possible through effective preparedness. The remarkable vision this strategy is to develop Nepal as a disaster-resilient community. Besides this, the strategy has been adopted the following directive principles for disaster risk management.

a. Mainstream DRR concept into the development plan
b. Ensure life safety and social security
c. Give emphasis to gender and social inclusion
d. Adopt decentralize process of implementation
e. Follow the holistic approach
f. Give priority to staff safety and security
g. Follow one-window policy and cluster approach in implementation of DRM
h. Work in the spirit of participation, interaction, and coordination

As this disaster management multidimensional subject, sectorial strategies has been used which as are divided to nine areas; Agriculture and Food Security, Health, Education, Shelter, Infrastructure and Physical Planning, Livelihood Protection, Water and Sanitation, Information, Communication, Coordination and Logistics, Search and Rescue and Damage and Need Assessment. Further the strategy has foundation five priority actions of HFA 2005 and 29 activities within priority areas.

Besides, it also envisions National Disaster Management Authority (NDMA) as a secretariat of the council where other three committees under the council for preparedness, rescue and relief and reconstruction and rehabilitation activities.

The strategy realizes that disaster management is possible only through integrated, participatory and collaborative involvement of all partners. As such due importance is given to UN agencies, donor community, inter-governmental agencies, I/NGOs, and people from different segments of civil societies.

Disaster Preparedness and Response Plan (DPRP) in Districts, 2010

The Ministry of Home Affairs (MoHA) has formulated District Disaster Preparedness and Response Planning Guideline (DPRP) under the guidance of CNDRC aimed at formulating emergency preparedness for response at all districts. Under the leadership of the District Disaster Relief Committee, the DPRP process has been scaled up with the technical support of District Lead Support Agencies (DLSA), successfully covering 73 districts by 2012.

National Disaster Response Framework (NDRF)

National Disaster Response Framework (NDRF) has been prepared for effective coordination and implementation of disaster preparedness and response activities by developing National Disaster Response Action points that clarify the roles and responsibilities of the government and non-government agencies. The main purpose of this framework is to develop a clear, concise and comprehensive national disaster response framework for Nepal that can guide a more effective and coordinated national response focusing on large scale disaster.

2.6 Institutional Mechanism

Ministry of Home Affairs (MoHA) acts as National Focal Agency on Disaster Management and lead agency responsible, for implementation of the Natural Calamity (Relief) Act, 1982. Besides, under MoHA, various institutional arrangements are developed at different administrative level.

Central Natural Disaster Relief Committee (CNDRC)

CNDRC is chaired by the Home Minister and includes related ministries and security agencies along with voluntary organizations such as NRCS. CNDRC has to prepare national policies on preparedness, response and recovery and ensure their implementation.

Regional Disaster Relief Committee (RDRC)

Regional Administrator has chaired RDRC which is presented in all five regions of Nepal. It comprises related government agencies and security agencies (law and order, emergency response and development institutions) along with voluntary organizations such as Red Cross.

District Disaster Relief Committee (DDRC)

All 75 districts of Nepal have a DDRC. The role of DDRC is to coordinate the local committees, formulate district disaster management plan, coordinate and operate relief work during emergencies and provide information to RDRC and CNDRC.

Local Disaster Relief Committee (LDRC)

The committee is responsible for disaster management at the local level, such as disbursement of funds during emergencies, and rescue and transport of the injured to hospitals.

Aftermath the great earthquake 2015, 25th April, Nepal has had number of strategy to address post earthquake reconstruction and resettlement.

Reconstruction and resettlement Act 2015 (2072)

The Legislature-Parliament set forth in clause (1) of Article 296 of the Constitution of Nepal has made this Act on 20th December 2015. it is expedient to make legal provisions on the establishment of an empowered National Reconstruction Authority in order to promptly complete the construction works of the structures damaged due to a devastating earthquake of 25 April 2015 (12th Baishakh 2072) and subsequent aftershocks, in a sustainable, resilient and planned manner, and to promote national interests and provide social justice by making resettlement and translocation of the persons and families displaced by the earthquake;

National Reconstruction Authority

National Reconstruction Authority bill was passed with unopposed in 25th December 2015 with authority to fulfill the objective of Reconstruction and Resettlement Act 2015 after appointment of the Chief Executive Officer. This Authority is established to generate resources and created an environment for the reconstruction after earthquake disaster 2015. It if fully responsible to coordinate between numbers of ministry for the objective. Major ministry was Urban Development Ministry, Ministry of federal Affairs and Local Development, Education Ministry and Ministry of Culture, Tourism, and Civil Aviation.

Post Disaster Recovery Framework 2016-2020

National Reconstruction Authority prepared Post Disaster Recovery Framework 2016-2020 on May 2016 (NRA, 2016). Major strategic objective of this framework are:

1. Restore and improve disaster resilient housing, government buildings and cultural heritage, in rural areas and cities
2. Strengthen the capacity of people and communities to reduce their risk and vulnerability, and to enhance social cohesion
3. Restore and improve access to services, and improve environmental resilience
4. Develop and restore economic opportunities and livelihoods and re-establish productive sectors
5. Strengthen capacity and effectiveness of the state to respond to the people's needs and to effectively recover from future disasters

2.7 Identification and allocation of Open Space as Emergency Response Plan

Open space is area of land either remains in its natural state or is used for agriculture, free from intensive development for residential, commercial, industrial or institutional use (DEC, 2015). Open space on the context, in landuse planning, urban open space is open space areas for parks, green spaces and other open area. Typically, open space includes parks, gardens, trails, habitat corridors, utility reserves, sports grounding and conservation reserves. Open space is related with post disaster phase of emergency planning, as the area for temporary relocation as well as healthcare and rescue activities can be done efficiently for the earthquake evacuees from these areas (UNDP/ERRRP, 2009). In Pokhara sub-metropolitan city, the forty-seven open spaces were identified and ranked them based on the spatial analysis methodology, where, the 500 m coverage buffers of each open spaces is created and the services facilities such as hospital, clinics, police station, CBOs that are within the 500 m buffer area of the open space is analyzed in a GIS base for the evaluation of the suitability and functionality of the open space. Open space is required for per person 3.5 sq. m including circulation area, which is approximately 38 sq. ft of area per person (IOM, 2010).Seven Potential collective center locations were selected in Lalitpur municipality and ten potential area were chosen in Kathmandu municipality which parameters were available normal circumstances, infrastructural facilities such as sanitation, hygiene and security concerns. NSET had identified fifty-three open spaces for Emergency shelter in Bhaktapur and three hundred forty-six emergency shelters in Lalitpur district.

2.8 Research Gaps

All the previous researches were mainly concerned at seismic vulnerability within Kathmandu Valley and eastern part of the country and basically intense one aspect either construction materials or the technology. Very few researchers had undertaken in the western part of country and low research has covered all the aspect which involved during the earthquake. Most of them had tried to evaluate only residential and historical temples mainly concentrating in construction materials and technical side less priority has given to socio-economic issue. Previous researches had undertaken about seismic vulnerability and evaluation of building destroyed but they hadn't shown any concern about earthquake response plan, Management plan and evacuation sites with open space. The present research attempts to cover all types of buildings including temples, government offices and non-government offices with their physical condition for earthquake hazard and prediction with the help of GIS method. So this research has done a small part of Thecho VDC attempting to cover all type of building, including lifelines and response plan for earthquake as well as people awareness in earthquake.

Based on literatures reviewed and research gaps identified, conceptual frameworks developed as following for the current study:

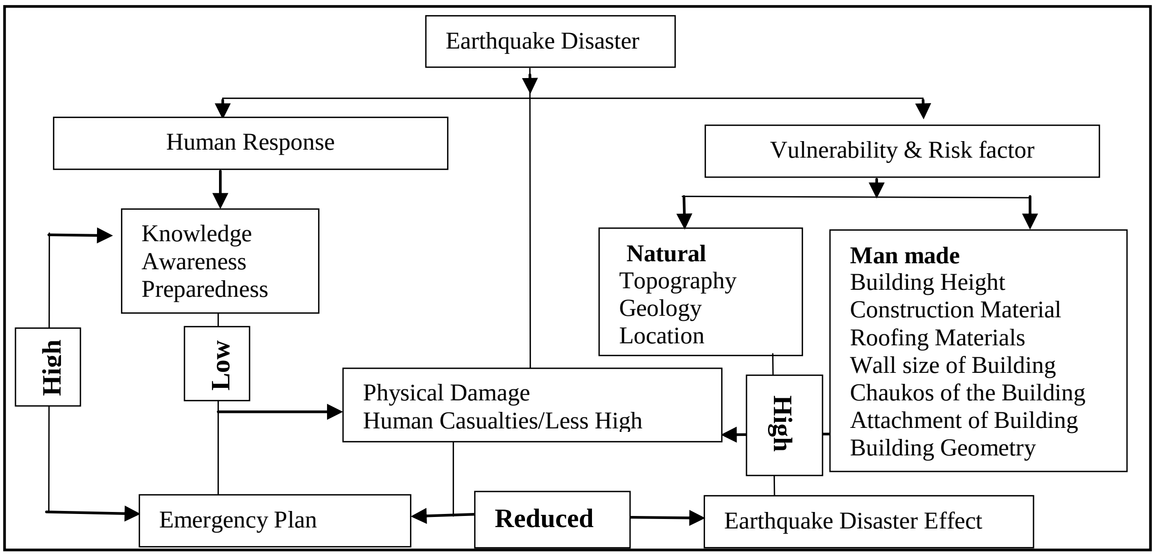


Figure 5. Conceptual Framework of the Research Study

CHAPTER III

RESEARCH METHODOLOGY

3.1 Study Area Selection

Even smaller in area (3 sq km), Thecho VDC is enrich in culture, having multi-racial people, who celebrates different festival and follow various traditions. It is culturally, historically important as it is ornamented with different temples, cultural heritage. It is one of the oldest settlement in which total population of 10,086 can be found which is suitable to declare as municipality. This place is important from the point of view of business as this village is moving towards urbanization where people are living the farming and engaging in different occupations.

The data of CBS 2011 shows that there is 10,086 population and 2,352 households in this Thecho VDC and the growth rate of population in village is 2.58% per year (CBS, 2011). The remarkable critical fact is the rapid construction of houses without registration as told by an Office Assistant of VDC. This concludes that this area is on the way to be urban and here is high population growth, high density, improper landuse planning, haphazard building constructions and low level of public consciousness, these all reasons shows that there is high possibility of high losses and destruction during disaster

3.2 Nature & Sources of Data

The Research Methodology is a backbone of research paper because it is a way of data collection, data manage and data presentation. The word methodology is created by the combination of two words “method and techniques” where method means choice of techniques and techniques means useful tools so it can be called major part of data collection in research. It provides a whole process and sequences of the study. To conduct a research in a systematic way requires a methods and such methods and technique have been applied in this work.

This research was started from selected the research theme, which was first part of this research then review of related literature, narrowing a focus of topic then development of proposal, questionnaire development, field map collection and preparation at the end building inventory sheet development.

The second part of this research was started from collecting primary and secondary data. The secondary data was collected from the VDC office, Thecho, Central Bureau of Statistics (CBS), National Society for Earthquake Technology (NSET) and Department of Mines and Geology (DMG). In this way the primary data (qualitative and quantitative) was collected from the field survey which was conducted during 26 November to 12 December 2015. Where, information of building characteristics was collected from visually observing of building and information of people awareness and preparedness was collected by visiting the household.

In this way, the third part of this work started digitizing the building footprint map. After that all attribute information of the building and household were entered in the excel sheet and linked in GIS. Likewise, in GIS, VDC boundary was overlaid by 200*200 Mesh. After all building vulnerability analysis was done in RADIUS tool. Complete procedure of the RADIUS methodology of this research is presented below.

Flow chart of the Research Methodology

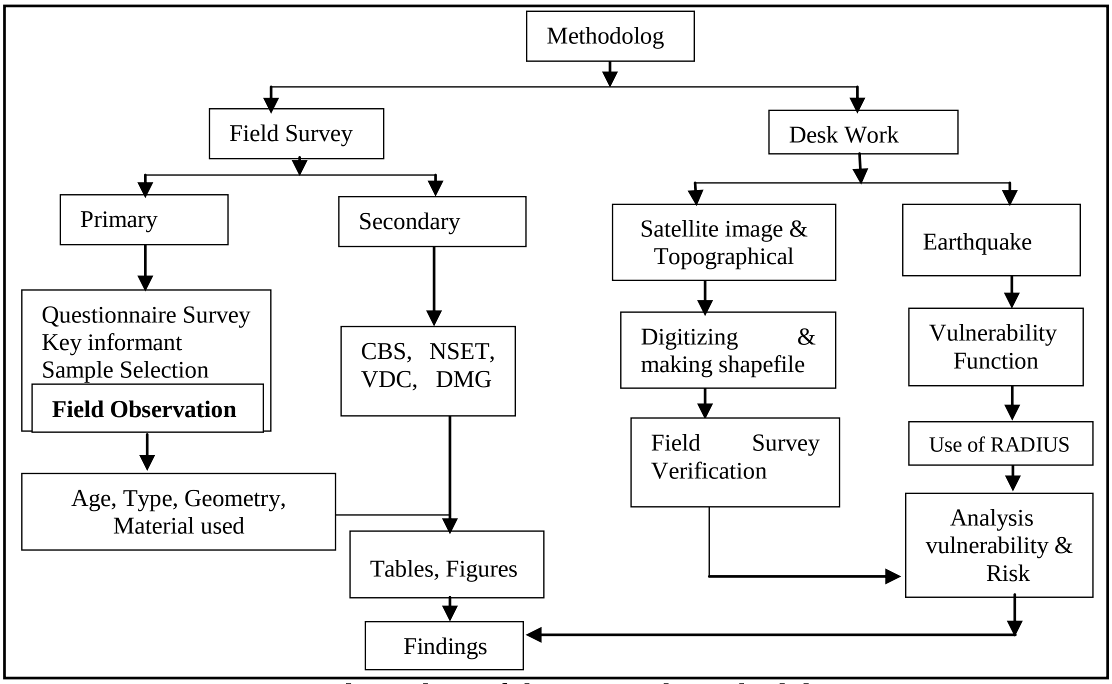


Figure 6. Flow Chart of the Research Methodology

The available data from primary and secondary sources has been processed by using descriptive statistical techniques. All spatial data has been analyzed in Google Earth Pro and Arc GIS 10.1 and Microsoft excel format to calculate the vulnerability of buildings.

3.2.1 Primary Data

The primary data were collected from the field survey. The field survey was conducted during November - December 2015. During the field survey individual building were identified visually and traced in the Google image and given unique identity of building ID. For the data collection, various methods had been used which were field observation, key informant survey, Household Survey. Field observation and key informant survey were carried out purposive random survey. Household survey and building vulnerability assessment survey were carried out through random sample. There are different sampling methods available for the collection of data. The random sample and purposive sample method were applied to collect information in study area.

3.2.1(a) Field Observation

Observation method was used to collect to different parameter of the buildings, where random sampling method was applied to collect the building information for the building venerability assessment. In the study area, habitat of core area has given more priority during the collection the information because the habitat of core area have high risk of earthquake due to unplanned settlement, present of other infrastructure and lack of open space. Out of the total buildings of the VDC, eighty three building were observed and collected the information from the study area.

3.2.1(b) Key Information Survey

Key information survey was used to collect the information, where purposive sampling method was applied at VDC level awareness, preparedness and knowledge of earthquake. For this, schools, youth clubs, Red Cross, health post, Guthi, Mahila Samuha and DRM were also visited for their knowledge and preparedness as well as to known about their contribution in earthquake awareness and preparedness in the community. Fifteen key informants were selected for the historical information of earthquake which focused 70 above age (elder people) using purposive sample method (also known as a judge mental sample) which is also known as subjective sampling method (Kithcin & Tate, 2000)

3.2.1(c) Household Survey

The household survey was done to collect the information about respondent's awareness and preparedness on earthquake. The sample households were selected from total household. Out of total household, eighty three households were observe and used questionnaire during the research phase, Questionnaire survey was also done to get information about education status, ethnicity, religion, awareness and preparedness of earthquake.

3.2.1(d) Sampling

To identify the building and get information of study area, wards wise, eighty-three house hold were used by applied random sample method. Similarly, random sample method was applied for collecting the information of the building characteristics and level of awareness and preparedness level of study area. Random Samplings is one of data collection method, which is free from prejudice and unbiased when sample were selected (Adhakari & Gautam, 2009). Data collected from random sampling method represent the population character. This method is possibility of more intensive for study and come accuracy results.

In this research, random sampling was implemented building were selected randomly in each ward for build vulnerability assessment during the field survey, individual houses were identified visually and traced in map and giving numbers and house IDs. Indeed, the main habitat was given more priority to get information of building then other isolated settlements. In this way, youth clubs of Thecho VDC, schools, Red Cross society, DRM, Health post, Mahila Samuha and Guthi were visited to get the information of awareness and preparedness. Table shows the distribution pattern of sampled household in different wards in the study area.

Table 2. Distribution of sampled households and building vulnerability assessment survey in different ward

Wards. No	Total Houses	Sampled Household	Household Percent
1	266	13	16
2	113	8	10
3	126	7	8
4	171	10	12
5	122	7	8
6	203	9	11
7	76	5	6
8	106	6	7
9	452	18	22
Total	1635	83	100

3.2.1.(e) Post Earthquake Building damage assessment caused by earthquake 2015

Building damaged caused by the great earthquake of 25th April 2015 was determined and spatially located in the map through field survey. It data was used to compare output of RADIUS run in different earthquake scenario and Gorkha earthquake scenario.

3.2.2 Secondary Data

Secondary data were collected from various sources. The base map of the VDC, geological map, toposheet was collected from Department of Survey and Department of Mines and Geology. Similarly, VDC profile was collected from the VDC office, Thecho. Likewise, other published and unpublished books, journals, dissertations, related reports on this study were review from the Tribhuvan University, Central Library and NSET-Nepal-library, and Central Department of Geography.

Table 3. Sources and Nature of Data

S.N	Description	Sources	Map Scale	Year
1	Population and House Hold	VDC Profile of Thecho		2008
2	VDC toposheet map	Survey Department	1:125000	
3	Geological map of VDC	Mines and Geological Department	1:500000	2015
4	Primary data	Field survey		2015

3.3 Data Analysis

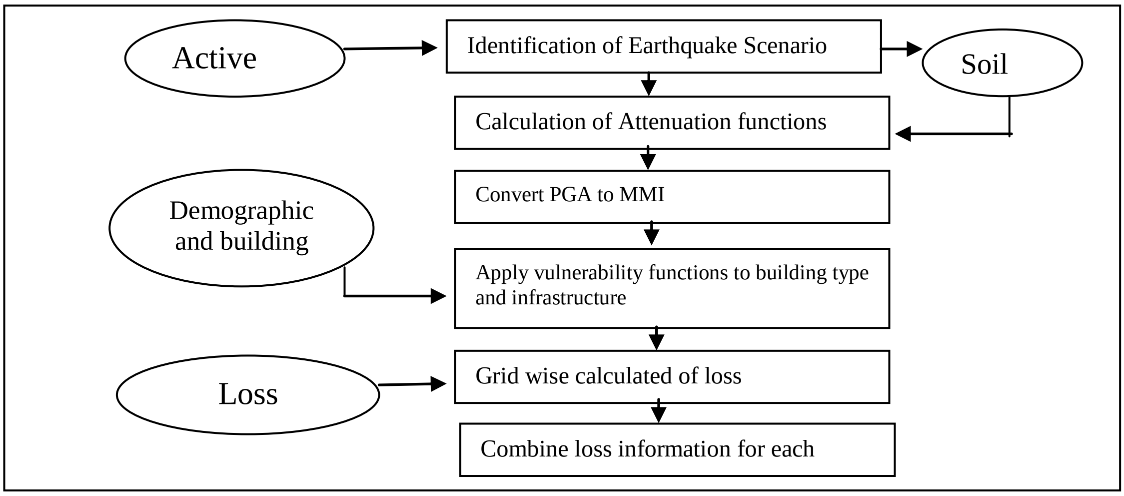
3.3.1 Data Processing- Arc GIS

GIS is a cross-platform free and open source desktop geographic information application that provides data viewing, editing, and analysis capabilities. This software allows creating maps with many layers using different map projections and also composed of raster or vector layer. The Geographic information system is a powerful set of tools for collecting, storing, retrieving at will transforming and displaying spatial data from the real world. It provides various capabilities like- data input, used to prepare the different map (land use map, drainage map etc.), beside this, it is used for editing and digitizing the shape map based on field survey. In this study, Arc GIS 10.1 software was used to prepare various maps. With the help of these tools, the nature and types of buildings and probability of buildings damage condition in different earthquake scenario can be estimated.

3.3.2 Data Analysis-RADIUS

Risk Assessment Tools for diagnosis of Urban Area against Seismic Disaster (RADIUS) is a simple computer tool has been use to estimate the earthquake damage. It was launched by the United Nations, as a contribution to the International Decade for National Disaster. Reduction is aiming to reduce seismic disasters in urban areas. RADIUS method is more appropriate to prepare fast earthquake scenarios that better fits in the needs of earthquake threatened cities in developing countries. To estimation of the building, this method was applied. The flow chart of the RADIUS method is given below.

Flow Chart of the RADIUS Method



RADIUS method divides the building class into 10 categories based on their material type, construction type, seismic code, occupancy type and number of stories (Villacis and Cardona, 1999). This classification is based on the common building type in Latin American cities. The methodology of RADIUS for building losses and casualty estimation can be divided into 10 steps (Western 2003, as cited in Tung, 2004) which are following;

Step 1: Defining earthquake scenario, location of epicenter, magnitude and depth.

Step 2: Calculate the attenuation using the function of Joyner & Boore (1981)

Step 3: Calculate the amplification due to local soil condition using the soil map.

Step 4: Convert the Peek Ground Acceleration to Modified Mercalli Intensity.

Step 5: Apply Vulnerability Function for Building type.

Step 6: Apply Vulnerability Function for Infrastructure type.

Step 7*:* Apply Vulnerability Function for Causalities.

If additional information on costs and PGA value for different periods is available, the analysis could be extended with the following step.

Step 8: Apply cost information to the building and combine with vulnerability to calculate losses for different return periods.

Step 9: Combine loss information for different return periods and calculate the risk by adding up the losses from these periods.

Step 10: Combine information and make summary.

Among all these steps, this study was continued up to estimation of vulnerability function for building, infrastructure type, causalities

Mesh

The mesh is a set of Excel cells, which define in the study area. In RADIUS Program, it is most important to create a uniformly spaced grid or mesh over the study area. A uniform mesh spacing of 200m to 5km is usually recommended by considering the size (scale) of the study area. The mesh space of the study area is considered as 200m (0.2 km) to estimation the earthquake scenario.

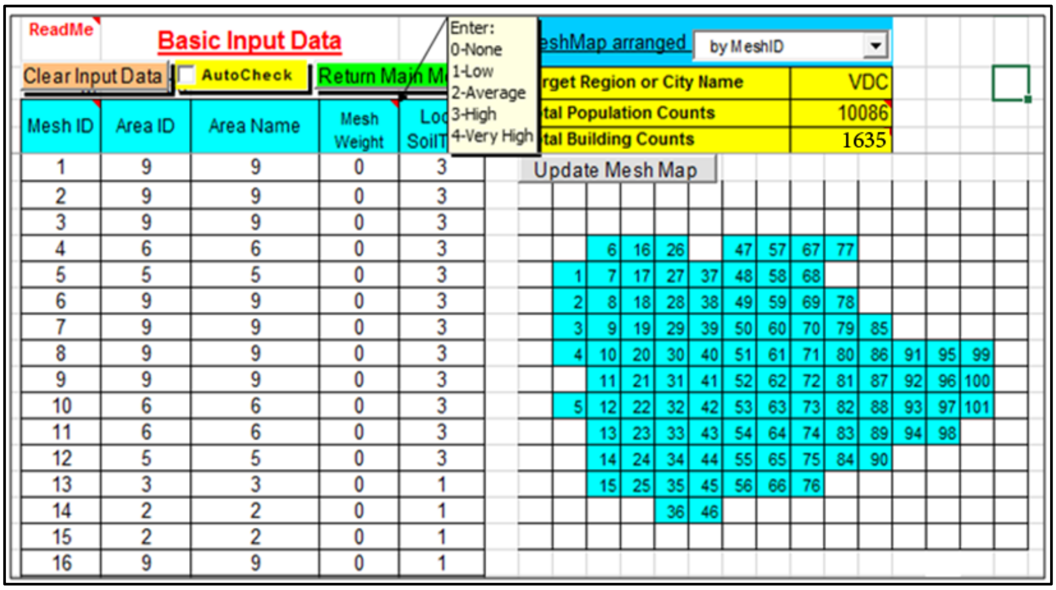
Mesh ID

After generate the mesh/grid, the unique identification number (ID) given to a mesh in the study area. The RADIUS Program automatically assigns Mesh ID values to meshes from left to right and top to bottom, after completing the mesh number input.

Area ID and Name

Several meshes comprise an area in the RADIUS tool. Area ID is the unique identification number (ID) given to an area, in the RADIUS tool Imagine a block or district or area made up of several meshes. In addition, there will be also enter the name of the Area ID (Figure 4.4) in the Area Name field, as the user would be able to identify easily with a name rather than a number. Such a classification system would simplicity the user in defining the building inventory. It was assumed that the building inventory distribution is same for all meshes falling in an Area ID. In this study, 101 Area IDs were defined considering 9 wards of the VDC in the Basic Input Data sheet on the RADIUS tool. In the Area Name field of this program, 9 ward were defined as the study area for study.

Table 4. Mess weight



Mesh ID	Area ID	Area Name	Mesh Weight	Loc SoilT
1	9	9	0	3
2	9	9	0	3
3	9	9	0	3
4	6	6	0	3
5	5	5	0	3
6	9	9	0	3
7	9	9	0	3
8	9	9	0	3
9	9	9	0	3
10	6	6	0	3
11	6	6	0	3
12	5	5	0	3
13	3	3	0	1
14	2	2	0	1
15	2	2	0	1
16	9	9	0	1

Mesh weight

Mesh weight are comparatively importance factors in radius program. It based on researcher’s views of what should be the relative building density for the study area. Table 10 shows that three types of Mesh Weight in RADIUS Program. Weight refers by the code, where 0 indicates no settlement or open area, 1 indicate scattered settlement and 2 indicate old settlement.

Table 5. Identification of Mesh Weight

Code	Description	Rate
0	None(open space)	0
1	Low(Scatter Settlement)	1
2	High(Core Settlement)	2

Source: RADIUS Analysis, 2015

These rates are used for distribution calculation of building counts in each Mesh and Area. In this study, three types of Mesh Weight; 0, 1 and 2 were used to calculate estimate.

Local Soil Type

The soil type is very important in this program because of weak formation soil could be the high vulnerability of earthquake relative to the hard rock soil. In the Thecho VDC, there are two types of soil considering the RADIUS program which has defined according to the geological map of Thecho VDC.

Table 6. Soil Types of the Study Area

Code	Description	Amplification Factor
1	Hard Rock	1
2	Soft Rock	2

Source: RADIUS Analysis, 2015

Building Classification

Buildings were classified in Area ID Inventory sheet which may be classified according to the various parameters. There could be many ways to classify building types, but 10 building classes were adopted in RADIUS tool. These have been classified on the basis of the strength of buildings against shaking in an earthquake. The user is expected to enter the building inventory percentages for building classes in the target region, by Area ID, which most closely matches to the building classes in the RADIUS tool. An explanation of the building classes is given below:

Table 7.Building Classification in RADIUS Method

RES1	Informal construction: mainly slums, row housing etc. made from unburned bricks, mud mortar, loosely tied walls and roofs, such as adobe.
RES2	URM-RC composite construction: sub-standard construction, not complying with the local codal provisions. Height up to 3 stories. URM is un-reinforced brick or stone masonry, while RC is steel reinforced cement concrete construction.
RES3	URM-RC composite construction: old, deteriorated construction, not complying with the latest codal provisions. Height 4 - 6 stories
RES4	Engineered RC construction: newly constructed multi-storied buildings, for residential and commercial (shops and offices) purposes.

EDU1	School buildings, up to 2 stories: Such buildings usually constitute a very small percentage of the total building counts.
EDU2	School buildings, greater than 2 stories: Such buildings usually constitute a very small percentage of the total building counts.
MED1	Low to medium rise hospitals: Such buildings usually constitute a very small percentage of the total building counts.
MED2	High rise hospitals: Such buildings usually constitute a very small percentage of the total building counts
COM	Shopping Centers and Shopping Malls: Such buildings usually constitute a very small percentage of the total building counts.
IND	Industrial facilities, both low and high risk.

Source: RADIUS Program

Vulnerability functions, which indicate the relation between seismic intensity rate for structural types, are determined as the function of acceleration/MMI based on damage observed during past sample earthquakes. The damage levels consider in this method is collapses and heavy damage.

3.3.3 Vulnerability and Damage analysis

Building inventory sheets and Questionnaire sheets were developed to collect the required information and data. The building inventory sheet was developed according to the type of building no. of floor age of building, construction material, roofing types, walls sizes and attachment/ separated with neighbouring building. The building classification is based on different parameters shown in following table.

Table 8. Building classification in the study area

Types	**Definition of Building**	**Level**
A	Building constructed with sun dried bricks with mud.	These are generally old traditional buildings.
B	Buildings are made by bamboo with mud.	
BC	Building constructed with bricks in cement.	These are related with modern building.
BM	Buildings are made by fried bricks with mud.	These are also traditional building.
RCC	Buildings are constructed with reinforced concrete framed cement.	These are generally newly constructed buildings.

Note:- A: Adobe, BC: Brick in Cement, BM: Brick in Mud, B: Bamboo, RCC: Reinforced Cement Concrete

Depending upon the age of the building, they are categorized into four groups.

Table 9. Four categories of building

Class	Building age	Description of Building age
A1	< 10 years	Buildings that are constructed within 10 years from now.
A2	10 to 20 years	Buildings that are constructed within 10 to 20 years from now.
A3	20 to 50 years	Buildings that is constructed within 20 to 50 years from now.
A4	>50 years	Buildings that are constructed within 50 years ago from now.

National Building Code, in the Nepalese context, indicates that to get a less damaging effect the building should be regular in plan and in elevation and the length and width ratio of the building must keep less than 3 (Jimee, Seisimic Vulnerability and Capacity Assessment at ward level; A case study of ward No 20, Lalitpur Sub -Metropolitan city, 2006).Buildings having large length to width ratio, large height to width ratio and large offset in plan and elevation, or irregular shaped building suffer greater damage during earthquakes than regular buildings (Guragain, 2004).

Depending on the Buildings Geometry (Shape) are classified into two categories.

Table 10. Categories of Building Geometry

Categories	Description
R1	Regular shaped buildings.
IR	Irregular shaped building.

If the buildings are too close together pounding induced by resonance may occur between the adjacent structures and add to the destruction therefore it is necessary to have some distance it is necessary to have some distance between the two buildings. If the buildings are attached and their floors are high, the building may be vulnerable. Besides, where the floor heights are short, it make low vulnerable.

Depending on these criteria, buildings in the study area has been classified.

Table 11. Classification of Building attachment

Categories	Description
AT	Buildings attached to the other buildings.
SE	Buildings separated from other buildings.

Note:- AT: Attached Building, SE: Separated Building

Depending on the wall size buildings in the study area has been classify

Table 12. Building classification based on wall size

Categories	Description
W1	<9” wall size
W2	9– 20” wall size
W3	>20” wall size

Depending on the Chaukos of the buildings in the study area has been classify.

Table 13. Building classification based on Chaukos type

Categories	Description
C1	Joint with rod
C2	Joint Elongated frame

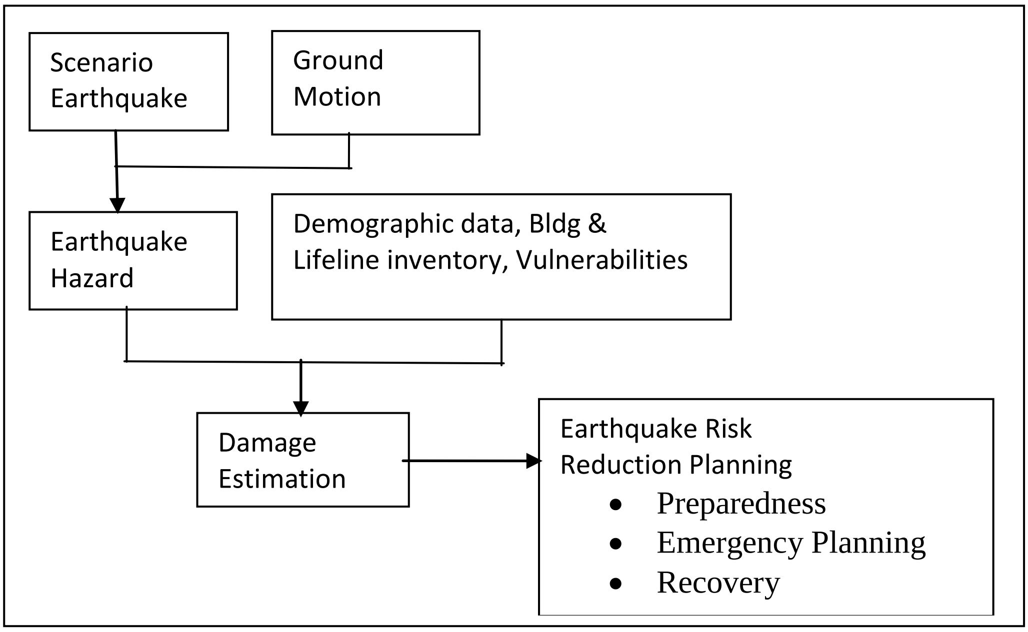
3.3.4 Vulnerability and Damage Estimation

To begin, a scenario earthquake for the area should be decided on. Reoccurrence of a past damaging earthquake or active fault earthquake is commonly assumed. The epicenter, magnitude, occurrence time (day or night) should also be determined. Usually, ground shaking intensity or PGA (peak ground acceleration) at the site generally becomes greater as the magnitude becomes larger or the distance from the site to the epicenter becomes smaller. Thus, Earthquake Hazard will be estimated from the parameters of the scenario earthquake and ground conditions. Damage will be estimated from hazard and the existing structures in the area and depends on not only the number of structures but also types of the buildings or lifeline facilities, using vulnerability functions derived for each type of structure. Casualties such as deaths and injuries are also estimated if the population distribution is known. Thus, the total amount and distribution of damage can be estimated if the chosen scenario earthquake were to occur. This research estimated 2 earthquake scenarios as follows:

Table 14.Earthquake Scenario

Earthquake Name	North	North-west
Fault Name	Main Central Thrust(MCT)	Lesser Himalayan Thrust(LHT)
Magnitude	7.6	6.5
Distance	37	2.55
Depth	20	20
Direction	North	North-west

Nepal has 92 different earthquake active faults in the eastern to the western part. Surrounding of the Thecho VDC there are two different types of active faults such faults are: Main Central Thrust (MCT) and Lesser Himalayan Fault (LHF).

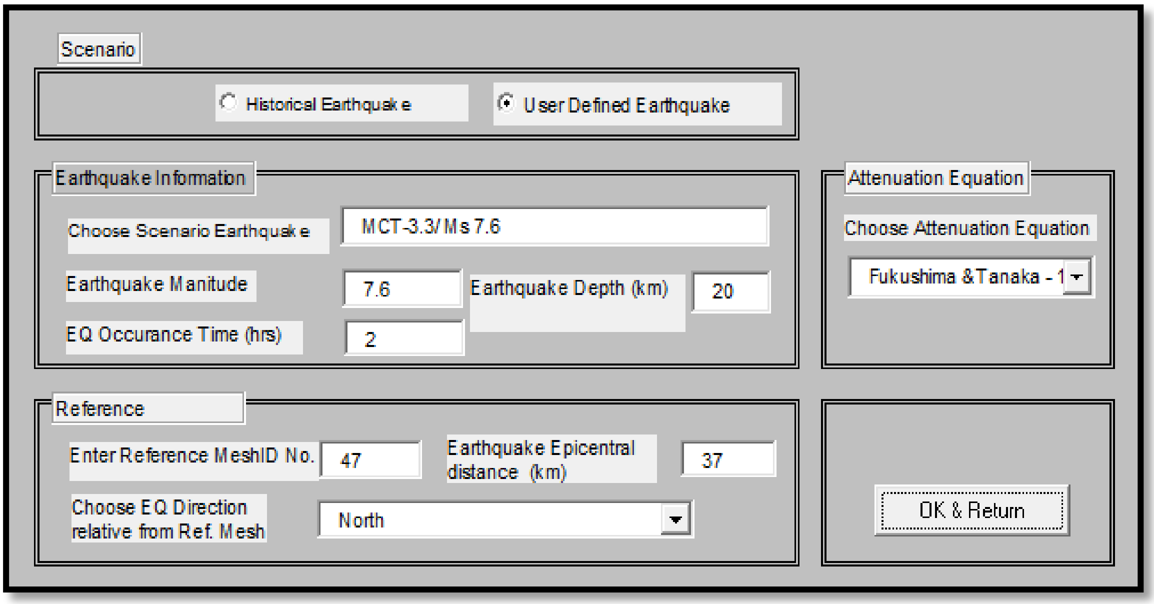


Source: *NSET, 2009(Modify)*

Figure 7. Outline of Damage Estimation in RADIUS Method

Figure shows about the outline of building damage and casualty estimation in RADIUS tool. According to this baseline, the researcher estimated about the building damage and causality by using following steps.

3.3.5 Defined Scenario Earthquake for Analysis



The earthquake scenario, which has defined by the researcher, earthquake parameters are to be defined by the user. This research has defined two types of earthquake scenario which is based on near fault line form Thecho VDC. Probability earthquake can be used as the scenario earthquake, it is important to be careful that the probability earthquake supplied in this tool is helpful when deciding scenario earthquake parameter. Inputs parameter for the scenario earthquake is location, depth, magnitude and occurrence time (day and night) of the earthquake. After creating these types of parameter the researcher (user) can run RADIUS tool to estimate the vulnerability of buildings and causalities. The RADIUS tool for calculating earthquake damage estimation, the researcher should have identified the study area, and also the total population 10086 and the total number of building 1635 within the study area.

CHAPTER IV

THE STUDY AREA

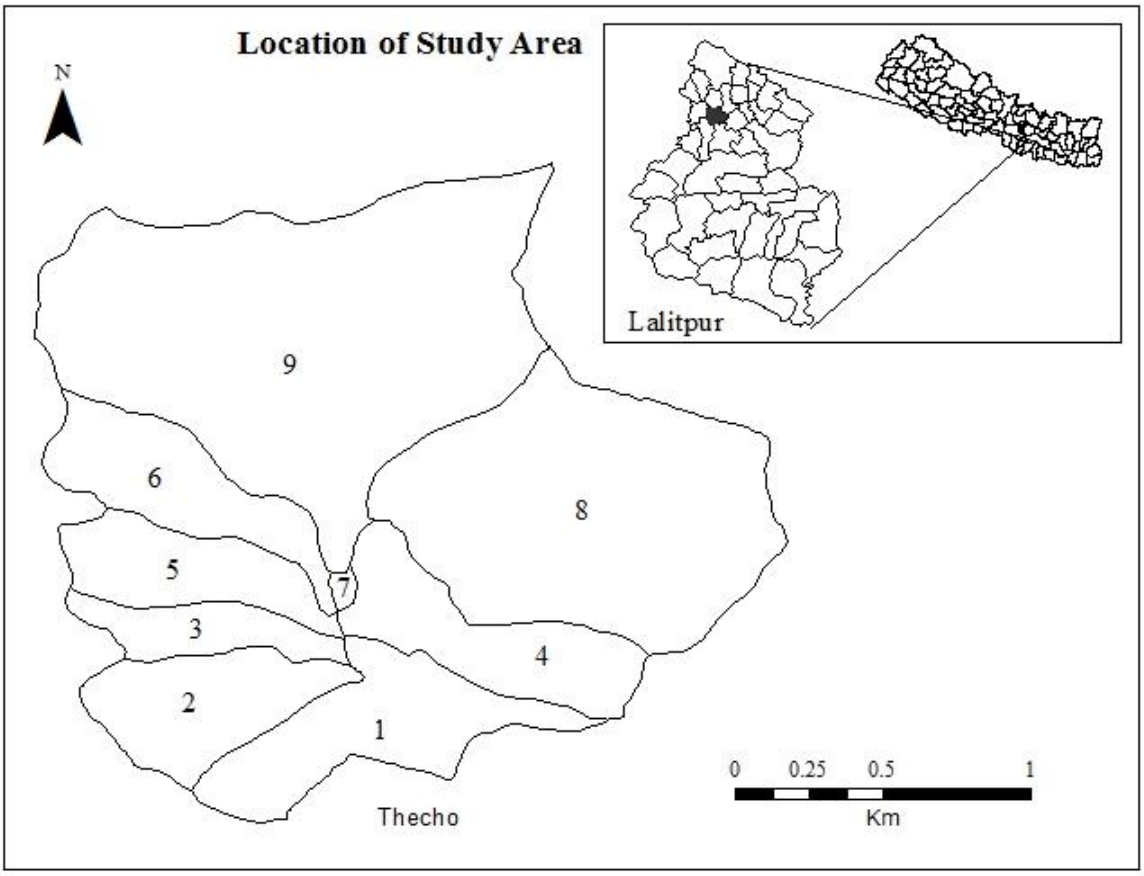
4.1 Physical Settings

The study will be conducted in Thecho Village Development Committee of Lalitpur District. Thecho VDC is located in Bagmati zone of Central Development Region. It is situated in 9 km in east from Mangalbazaar. There is Sunakothi village development committee in the south from where we can find that Kathmandu valley's plain land ends in its southern parts. From Sunakothi upward the terraced land starts. The village is surrounded by different neighboring villages like Jharuwarashi, Badigaun, Harishiddi, Godawari and Dhapakhel in the east, Bungamati and Khokana in the west, Sunakothi in the north and Chapagaun, Champii in the south.

It lies between 27^0, 36’30’’ to 27^0, 37’30’’ latitude and 85^0, 18’30’’ to 85^0 east longitude. It is about 4500 fit high from sea level and covered area 3.32 sq. km. The temperature of Thecho VDC is most moderate in the Kathmandu valley. In summer season the maximum temperature of this VDC is 32^0 C and the minimum temperature is from 1 to 3^0 C.

Thecho VDC is divided 9 wards and covers area is 3 sq km (CBS, 2011). The total population is 10086 among which 4942 are male and 5144 are female.

Thecho VDC is multicultural and multiracial community. A majority of the people belongs to ethnic communities of Newar, Brahamin, Chhettri, Tamang, Rai, Magar etc. Majority of people in this VDC practices Hinduism Buddhism, Christianity etc. The following map indicates about the location of the study area.



Source: (Thecho, 2008) and Modified fro Field Survey, 2015

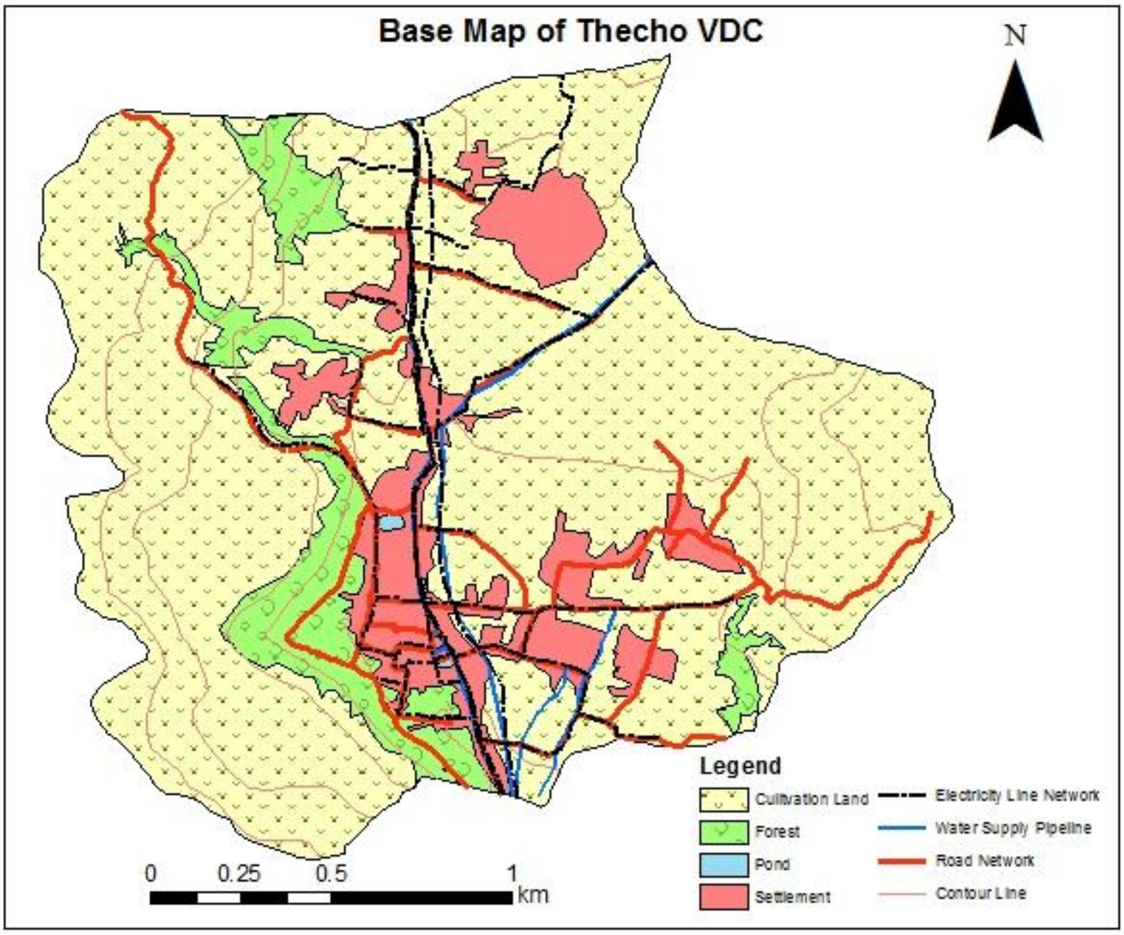
Figure 8. Location of Study Area

4.2 Landuse/Landcover

The land use pattern of the area is not more diverse because of small land which total area is only 3.321 sq. km. five types of land cover is found in Thecho VDC. Table 13 shows cultivation land covers 2.62 sq. km of the total land following by settlement area 0.396 sq. km, forest 0.302 sq.km and pond as water body 0.004sq.km.

Table 15.landuse type and area cover

Landuse Type	Area(sq. km)	%
Cultivation Land	2.619	78.8
Forest	0.302	9.1
Pond	0.004	0.1
Settlement	0.396	11.9
Total	**3.321**	**100**



Source: Source: (Thecho, 2008) and Modified fro Field Survey, 2015

Figure 9. Landuse map of Thecho

4.3 Contour Line

Thecho VDC lies 1380 m to 1460 m from the sea level. The contour line of the VDC is shown in figure. The counter line of this area shows the slope or relief feature in all the parts of the VDC, where maximum parts of the area is flat slope or gentle slope and some parts of the area is steep slope. Core settlement of the area like ward number 3, 4, 5 and 1 is find out gentle or flat slope area. Figure shows the relief feature of the study area

4.4 Drinking water Supply pipeline Network

Drinking water has been supplied by Nepal Drinking Water Corporation. Water is colleted in reservoir allocated in Taakhel from the ground water spring in Muldo, Nallu rivulet Lele VDC, Char Ghar. This water is distributed To Chapagaun, Thecho, Sunakoti, Dholahiti to Patan Sundhara.

4.5 Existing Transportation Network

Transportation Network is very important infrastructure for human being. This made our daily life easy and comfortable to move from one place to another for various purposes. The development of transportation contributes to develop the whole nation by strengthening the relationship between people and different area. This VDC covers all types of road. The total length of the road within the VD Encompasses 85.48 m. where Black topped road 10.31m, Gravelled 23.80m, Mud road 30.42m and stone paved 20.95m.

Table 16. Road Network in Thecho VDC

Road Type	Length(m)
Black Top	10.31
Gravel	23.80
Mud	30.42
Stone Paved	20.95
Total	**85.48**

4.6 Electricity Line Network

Electricity is most important source of energy to work in various sectors. We cannot imagine our life without electricity in present day. Existing electricity is divided into two types i.e high volt and low volt. Here, high volt is 11000 volt and low volt is 220 volt.

4.7 Population

Population are essential part of country which is main property for the country, without population cannot do development and progressive work. Population can play vital role to improve their place where population are stay. The total population of Thecho VDC is 10086 people were divided into 9 administrative wards and covers area 3.32 sq. km (Thecho, 2008. There are around 1635 household (Dangal, 2015). The VDC represent male population is 4942 and female population is 5144.

Table 17. Population distribution

Ward. No	Household	Male	Female	Total
1	266	890	881	1771
2	113	315	346	661
3	126	240	253	493
4	171	551	580	1131
5	122	271	326	597
6	203	461	512	973
7	76	157	171	328
8	106	411	393	804
9	452	1638	1682	3320
Total	1635	4942	5144	10086

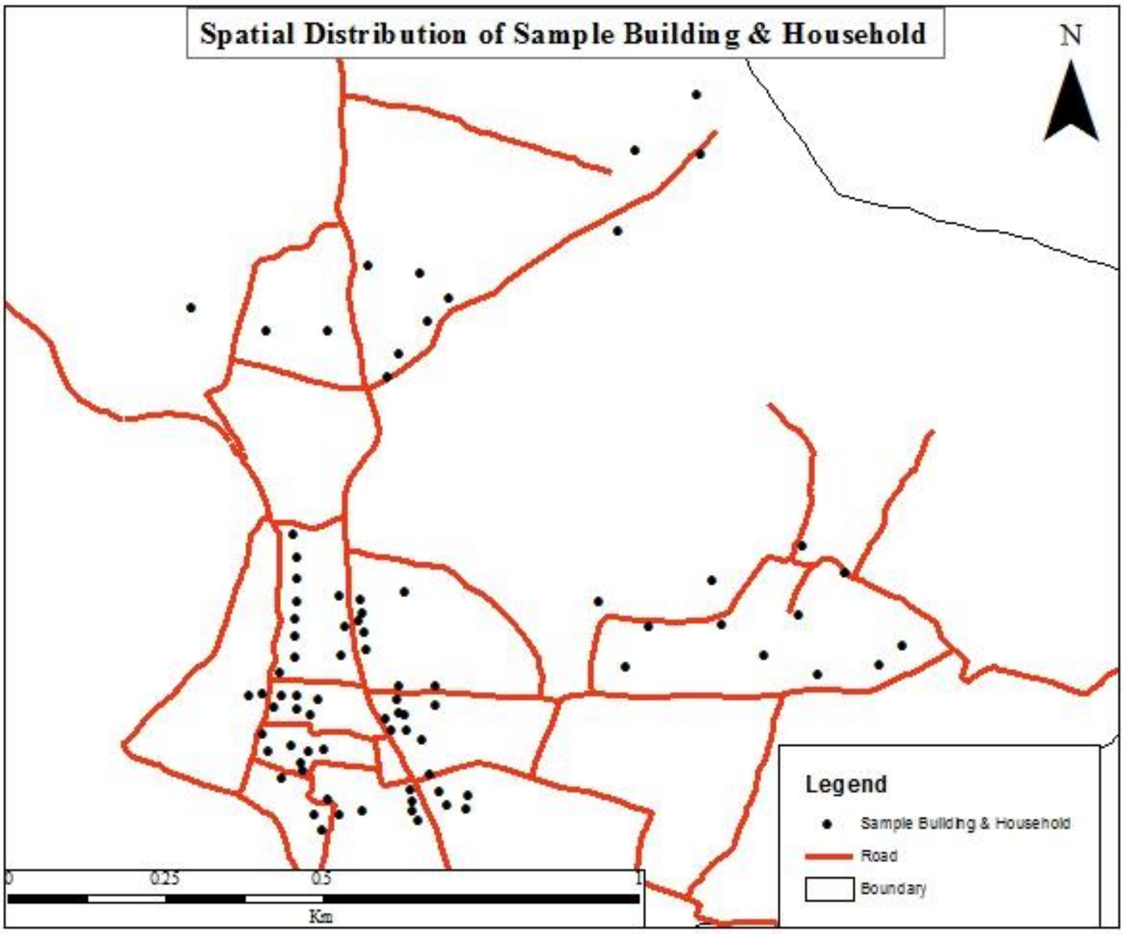
Source: (CBS, 2011)

CHAPTER V

BUILDING CHARACTERISTICS AND PAST EARTHQUAKE EVENT, RESPONSES

5.1 Introduction

Seismic Vulnerability of building is highly dependent on the space between buildings, buildings height, age of building, material used for construction. So it is necessary to know the building physical characteristic to identify the building vulnerability. Physical characteristic of buildings of Thecho VDC has been analysed in this chapter.



Source: Source: (Thecho, 2008) and Modified fro Field Survey, 2015

Figure 10. Spatial Distribution of Sample Buildings

Spatial Distribution of Building by Category

Buildings were classified according to building classification method given in RADIUS program in Area ID Inventory sheet. Where, building have classified according to the various parameters like their material types, construction type, uses, age stories etc. Earthquake damage to building is greatly influence by these parameters. Building class of 10 is adopted in RADIUS program. Here the user is expected to enter the building inventory percentages for building classes in the target region by Area ID or Area Name, which most closely matches to the building classes in the RADIUS program. Where Adobe buildings were classified in RES1, BM buildings were classified in RES2, BC buildings were classified in RES3 and Reinforce buildings were classified in RES4.

Table 18. Spatial Distribution of buildings

Ward	Adobe	Brick in Cement	Brick in Mud	Rein force
1	1	7	3	1
2	1	1	3	0
3	0	5	2	0
4	0	7	2	2
5	0	0	2	0
6	0	6	0	0
7	0	7	2	0
8	1	6	1	1
9	2	4	6	3

Lifeline Classification

Lifelines are very important factor on the earth surface which makes our life easy and comfortable. It seems direct relationship on human beings and these are necessary for the effective functioning and wellbeing of any society. In RADIUS Program lifelines can be used for earthquake damage estimation. There are many types of lifelines in the RADIUS programme although, some lifelines have Scale of the vulnerability in the table bellows

Table 19.Lifeline inventory

Read Me First | Data Clear | Return Main Menu | ☑ AutoCheck

LifeLine	Total Count	Unit	Definition
Road1	6	km	Length of Local Roads (in km), for the concerned city or target region.
Road2	6	km	Length of major roads such as Freeways/ Highways (in km).
Bridge	0	Count	Number of major Transportation Bridges (road and railway).
Tunnels	0	Count	Number of major Transportation Tunnels, for the concerned city or target region.
Electric1	5	Count	Number of major Electrical & Telecommunication transmission towers.
Electric2	10	Site	Number of Electrical & Telecommunication sub-stations.
Water1	0	km	Length of major Water & Sewage trunk and distribution lines (km).
Water2	0	Site	Number of Water & Sewage pumping stations.
Water3	0	Site	Number of Water & Sewage treatment plants.
Reservoir1	0	Count	Number of Storage Reservoirs or Dams.
Reservoir2	0	Count	Number of Terminal Reservoirs or Elevated Storage Tanks.
Gasoline	0	Count	Number of Gasoline stations.

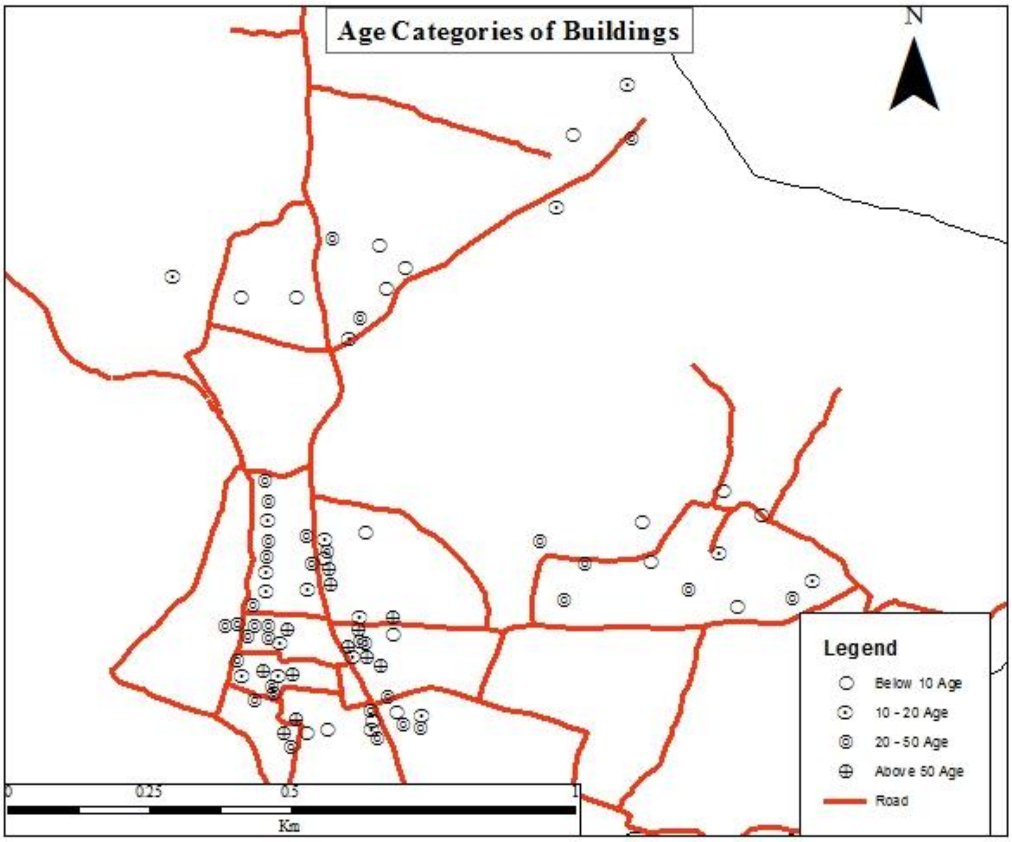
Table 20. Scale of vulnerability

Parameters	Scale of Vulnerability		
	High	Medium	Low
Use of construction materials	Adobe, BM	BC, B	RCC
Geometry	Irregular	-------------------	Regular
Attachment of building	Attached	-------------------	Separate
Age of building	A4	A3	A1 &A2
Wall size of building	W3	-------------------	W2 & W1
Chaukos	C2	-------------------	C1

Note: Above table shows the assumed scale of vulnerability of different building parameters which is categorized into three class i.e. high, medium and low.

Age of the Buildings

The total no. of building in Thecho according to census 2011 is 1365. The building age has been assumption and classified into four categories to find out the old and newly constructed building. For example; building aged less than 10 years and 10 to 20 years are new buildings which are generally made by brick with cement and reinforce concrete, joining from chaukos are iron rods and wall sizes are 9 and 14 inch.



Source: (Thecho, 2008) and Modified fro Field Survey, 2015

Figure 11. Age Categories of Building

Similarly, 20 to 50 years old buildings are categorised as old buildings which are generally made by brick with mud and brick with cement, having tile and tin roof. Likewise, the buildings having age more than 50 years are classified as oldest building, such types of building have found 18, 24 and 26 inch wall size, made by brick with clay which are attachment houses and joining from chaukos are Elongated Frame. According to age of buildings, old buildings are more vulnerable than others newly constructed buildings.

Table 21. Building Classification based on age of building

Age of Building	No. of household	Percent
< 10	18	21.89
10 – 20	18	21.69
20 – 50	35	42.17
>50	12	14.46
Total	83	100

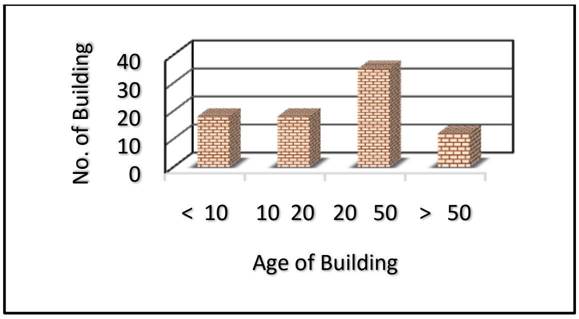


Figure 12. Histogram of Building type based on the age

In study area five types of buildings are used. Sun dried bricks with mud were used at old residential. These are generally old traditional buildings. Few buildings were made by bamboo with mud. Mostly buildings were constructed with bricks and cement which are found at core settlement. These are related with modern building. Most of fried bricks with mud building were found which also traditional buildings are. Reinforced concrete framed cement building were commonly found. Generally these building are newly constructed buildings

5.2 Buildings Height

Vulnerability of the building is also influence by the building height. When earthquake occur, building experiences acceleration, velocity and displacement of varying frequency. It is very obvious that higher the building height, higher the vulnerability and perhaps higher will be the human casualties. The adobe building high probability of being collapse compared to other building type followed by brick in mud and brick in cement buildings (Jimee, 2006).

In Thecho VDC different stories found from 1 storey to 4 stories with different floor. Three stories buildings were found more than other storey buildings which consists 51.81 percent. Where, one story buildings were found very few. Likewise 26. 51 and 13.25 percent buildings were found two and four storey respectively.

Table 22.Building Classification based on the height

No. of Storey	No. of Building	Percent
1	7	8.43
2	22	26.51
3	43	51.81
4	11	13.25

Source: Field Survey, 2015

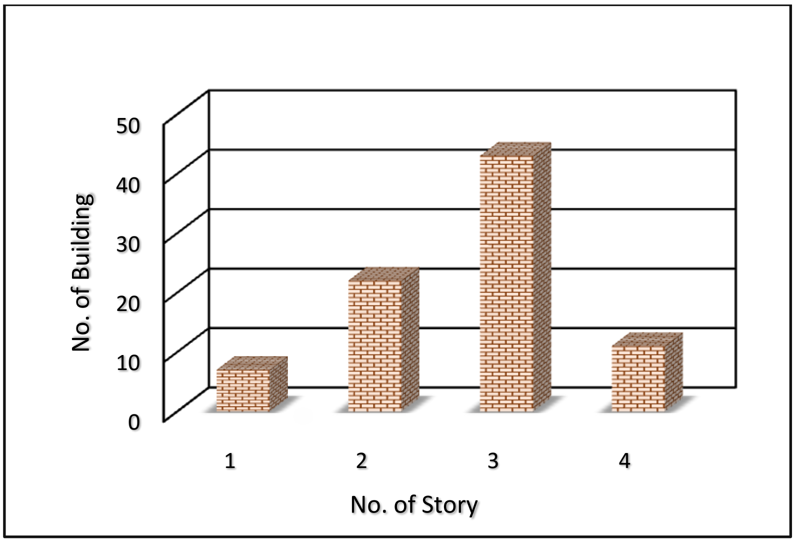
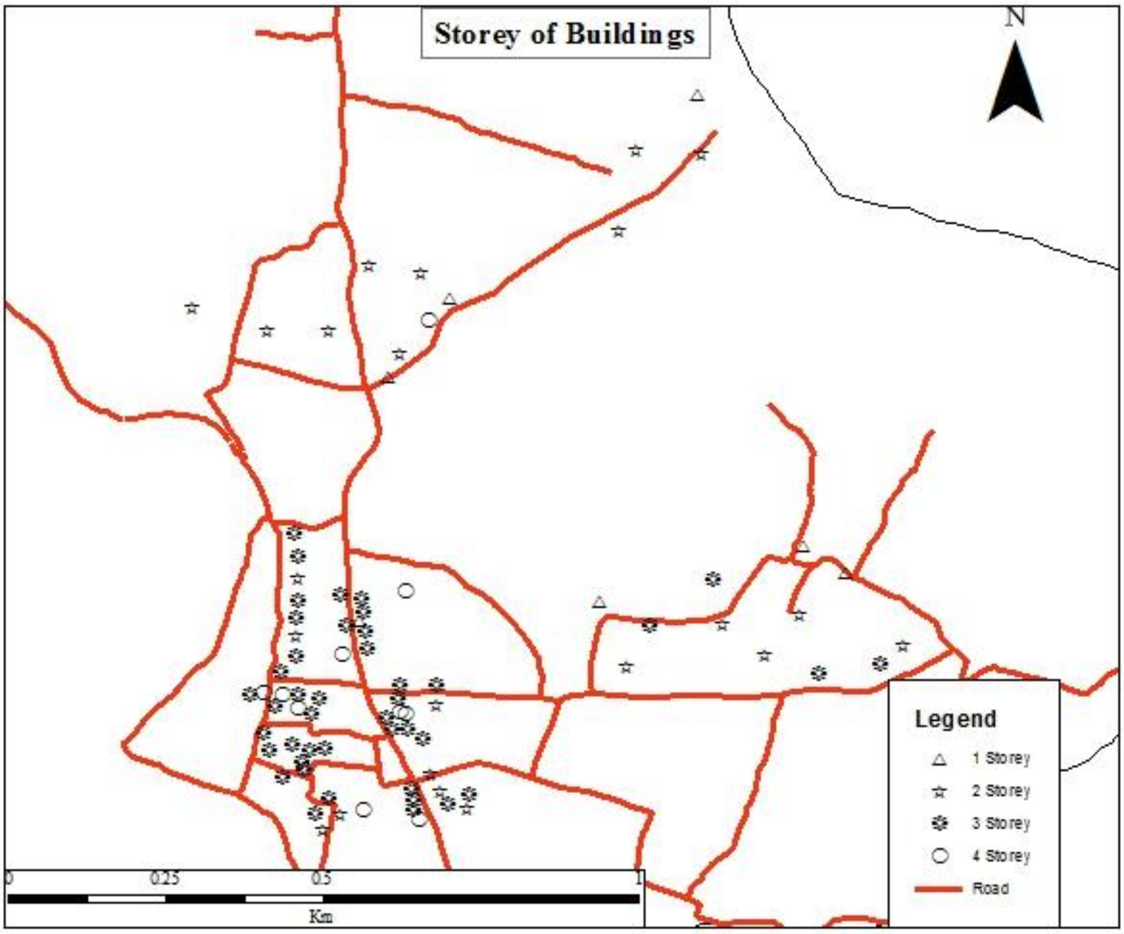


Figure 13. Histogram representation of building base on height

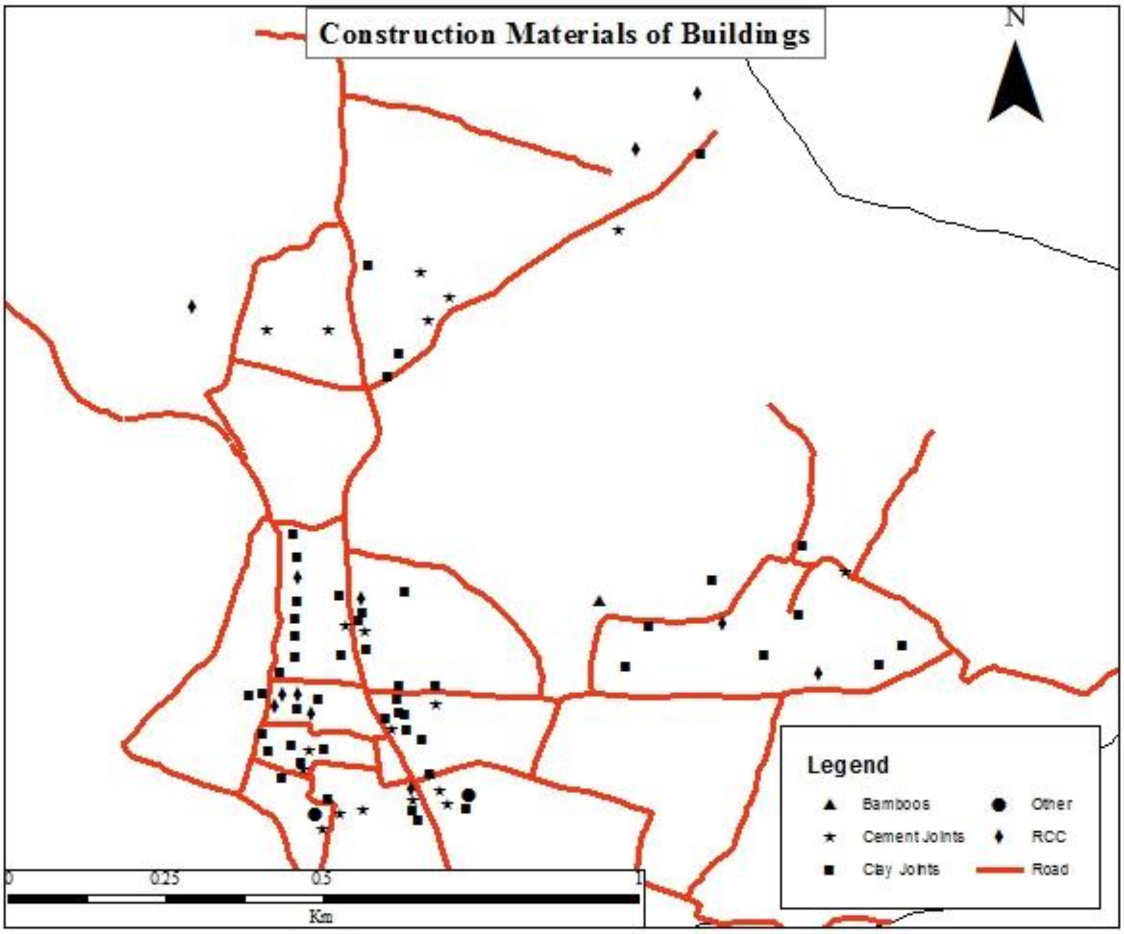


Source: (Thecho, 2008) and Modified fro Field Survey, 2015

Figure 14. Building Heights

5.3 Construction Material

The construction material is important part in building vulnerability which plays vital role in damaging the building in earthquake. Good construction materials like reinforce concrete used in building have more resistance as compared to the poor construction materials like Adobe, brick in mud etc. In the study area, 14.46 percent buildings were made with reinforce concrete and 22.89 percent building have used brick in cement, likewise 45.78 percent building were made with brick in mud, 15.66 percent building were adobe and 1.20 percent building have used bamboos.



Source: (Thecho, 2008) and Modified fro Field Survey, 2015

Figure 15. Building Materials Source: Field Survey, 2015

Table 23. Building classification based on the construction material

Construction Material	No. of Building	Percent
RCC	12	14.46
Brick in cement	19	22.89
Brick in mud	38	45.78
Adobe	13	15.66
Bamboos	1	1.20
Total	83	100

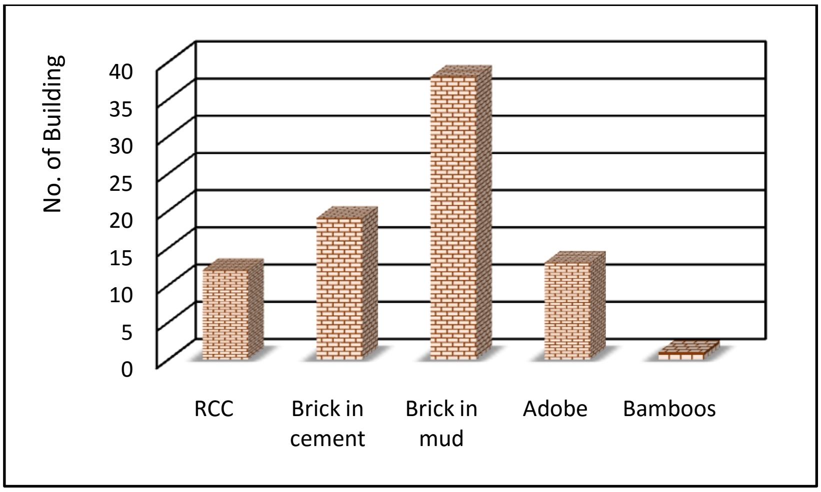


Figure 16. Histogram representing building based on construction materials.

5.4 Roofing Materials

Roofing materials also play important roles on vulnerability of the buildings. In the study area, four types of roofing materials were found, such as concrete, straw, tiles and tin etc. Among of them, 54.22 percent of the total buildings were made by concrete roof building, similarly, 25.30 percent, 19.23 percent and 1.20 percent building were with tile, tin and straw respectively.

Table 24. Types of building based on roof type

Roofing materials	No. of building	percent
Concrete	45	54.22
Straw	1	1.20
Tiles	21	25.30
Tin	16	19.28
Total	83	100

Source: Field Survey, 2015

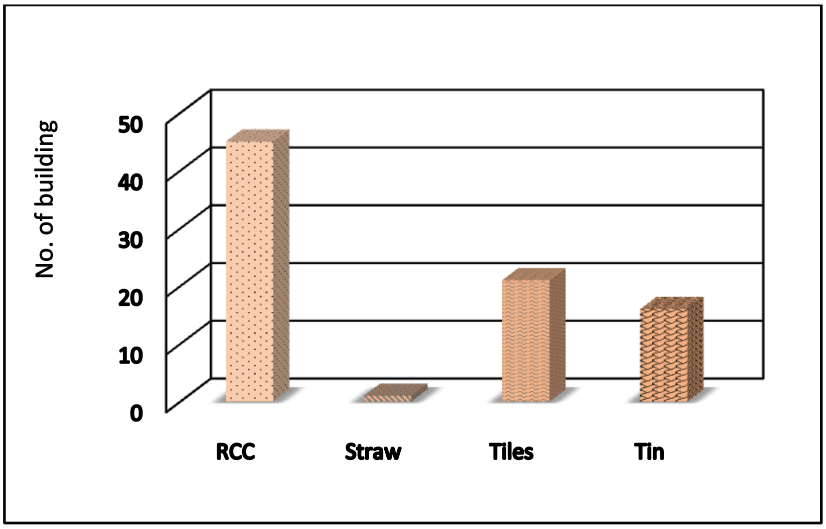
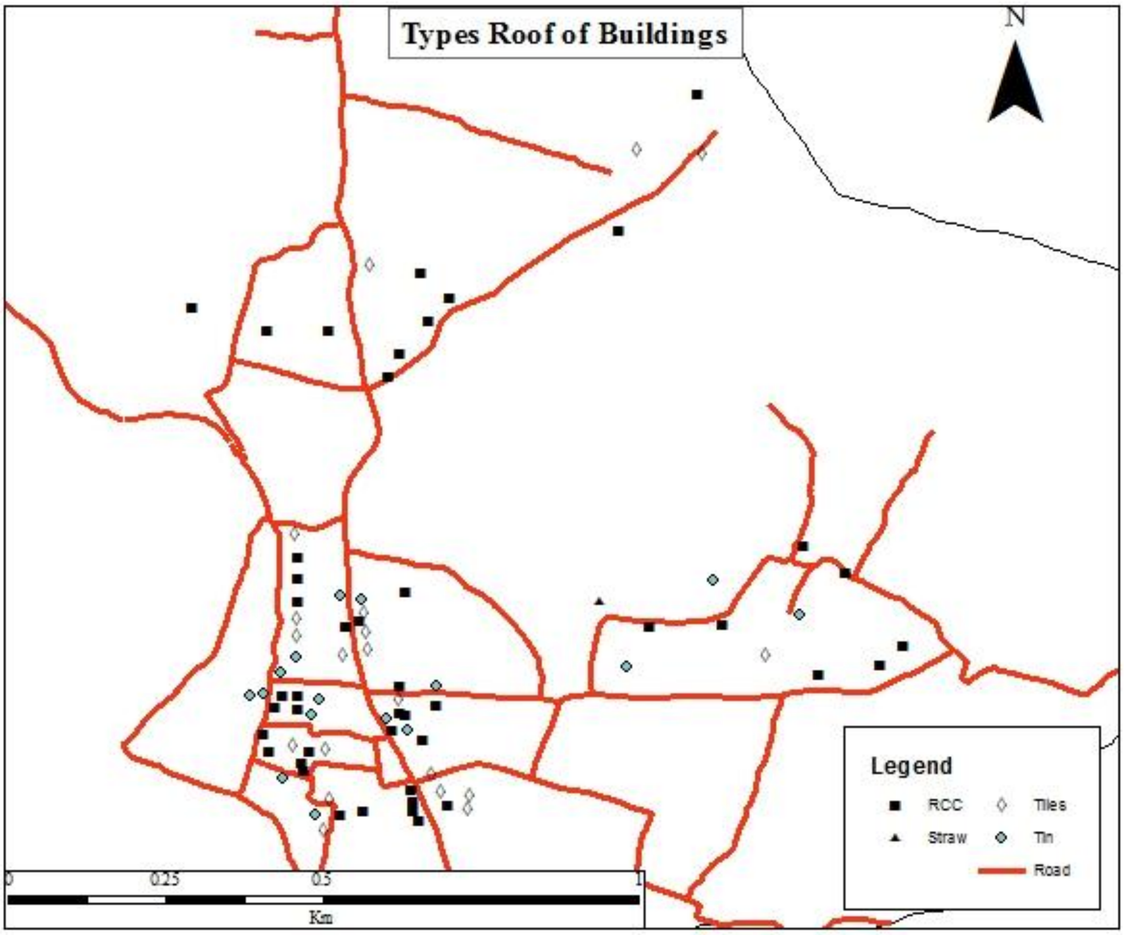


Figure 17. Histogram of building based on roof type.



Source: (Thecho, 2008) and Modified fro Field Survey, 2015

Figure 18. Roofing Materials

5.5 Wall size of Building

The wall size of building is one of important aspect of building vulnerability because width of wall determines the chance of building damage. In the study area, 9 to 20 inch wall size were common than the other wall size which consists 93.98 percent. Similarly, the wall sizes of below 9 inch were 3.61 percent and very few were above 20 inch compiling2.41 percent.

Table 25. Building classification based on wall size

Wall size	No. of Building	Percent
< 9	3	3.61
9 - 20	78	93.98
> 20	2	2.41
Total	83	100

Source: Field Survey, 2015

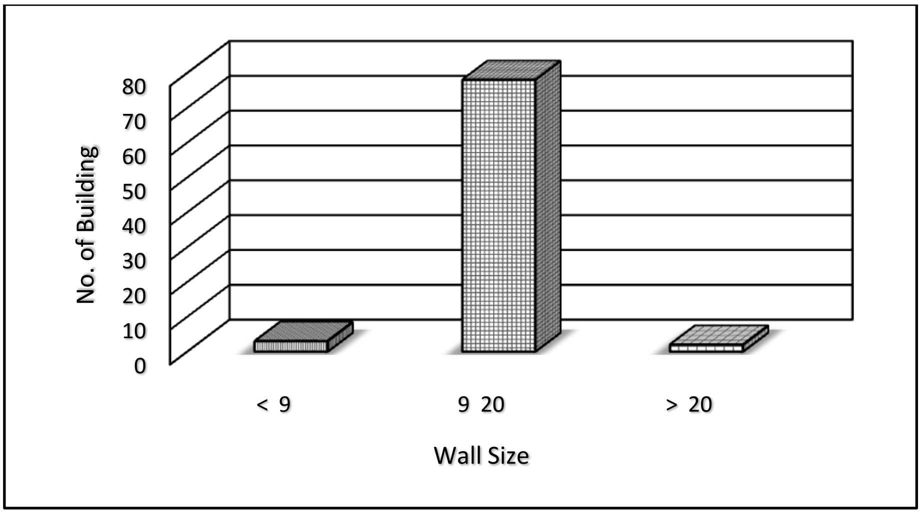


Figure 19. Histogram representing building based on wall size

5.6 Window frame of the Building

Window frame of the building also plays sensitive role for the vulnerability of the buildings. Mainly two types of Window frame were found in the study area. Where, 61.45 percent were found Elongated frame and 38.55 percent were found rod join Window frame.

Table 26. Building classification based on Window frame

Chaukos	No. of Building	Percent
Elongated Frame	51	61.45
Rod join	32	38.55
Total	83	100

Source: Field Survey, 2015

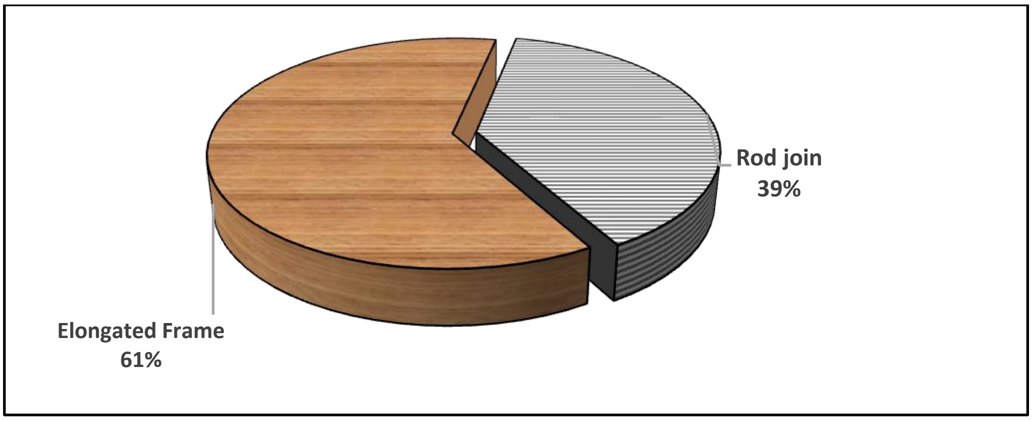


Figure 20. Pie chart representing Window frame of the buildings

5.7 Attachment of Building

Building attachment and separation also play important role on the vulnerability of the building. Attached buildings are more vulnerable than separate building. In the study area, it was found that, 68.67 percent of the total buildings were attached with the other building and about 31.33 percent were building not attached to other building.

Table 27. Building Classification based on attachment of building

Attached of Building	No. of Building	Percent
No attachment	26	31.33
Attachment	57	68.67
Total	83	100

Source: Field Survey, 2015

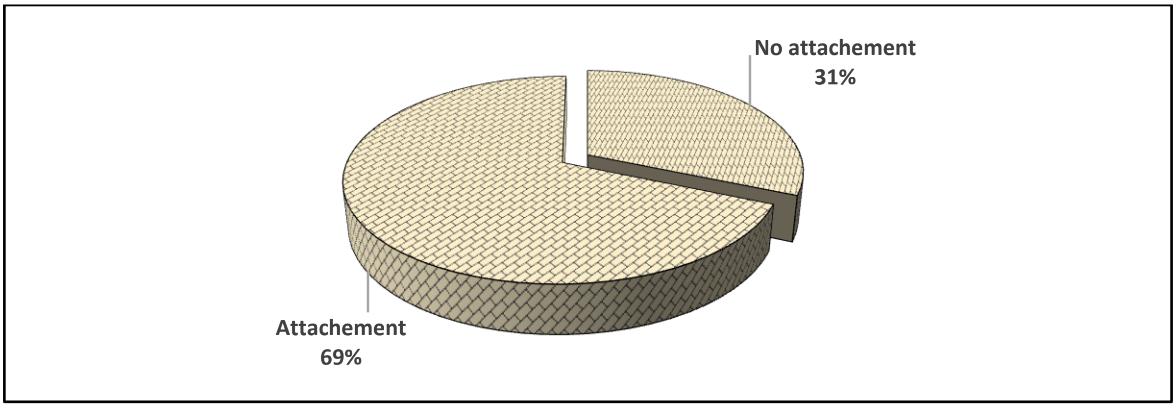


Figure 21. Pie chart representing attachment of building

5.8 Building Geometry

The factor of building vulnerability is also related to building. Buildings having large length to width ratio, large height to width ratio and large offset in plan and elevation, or irregular shaped building suffer greater damage during earthquakes than regular buildings (Guragain et al 2004). In the study area 9 (10.84 percent) buildings were found in an irregular shape and 74 (89.16 percent) buildings were in regular shapes which are shown below.

Table 28. Building type based on Geometry of building

Geometry	No. of buildings	Percent
Irregular	9	10.84
Regular	74	89.16
Total	83	100

Source Field Survey, 2015

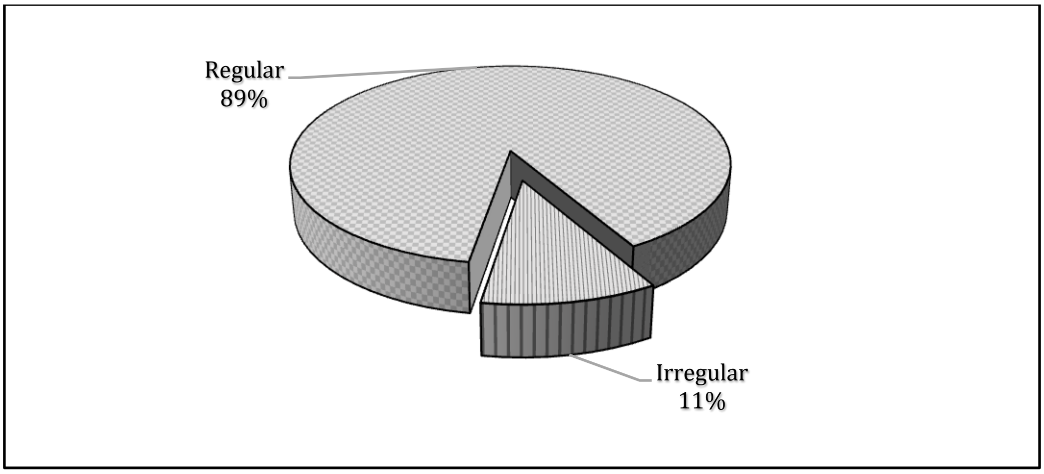
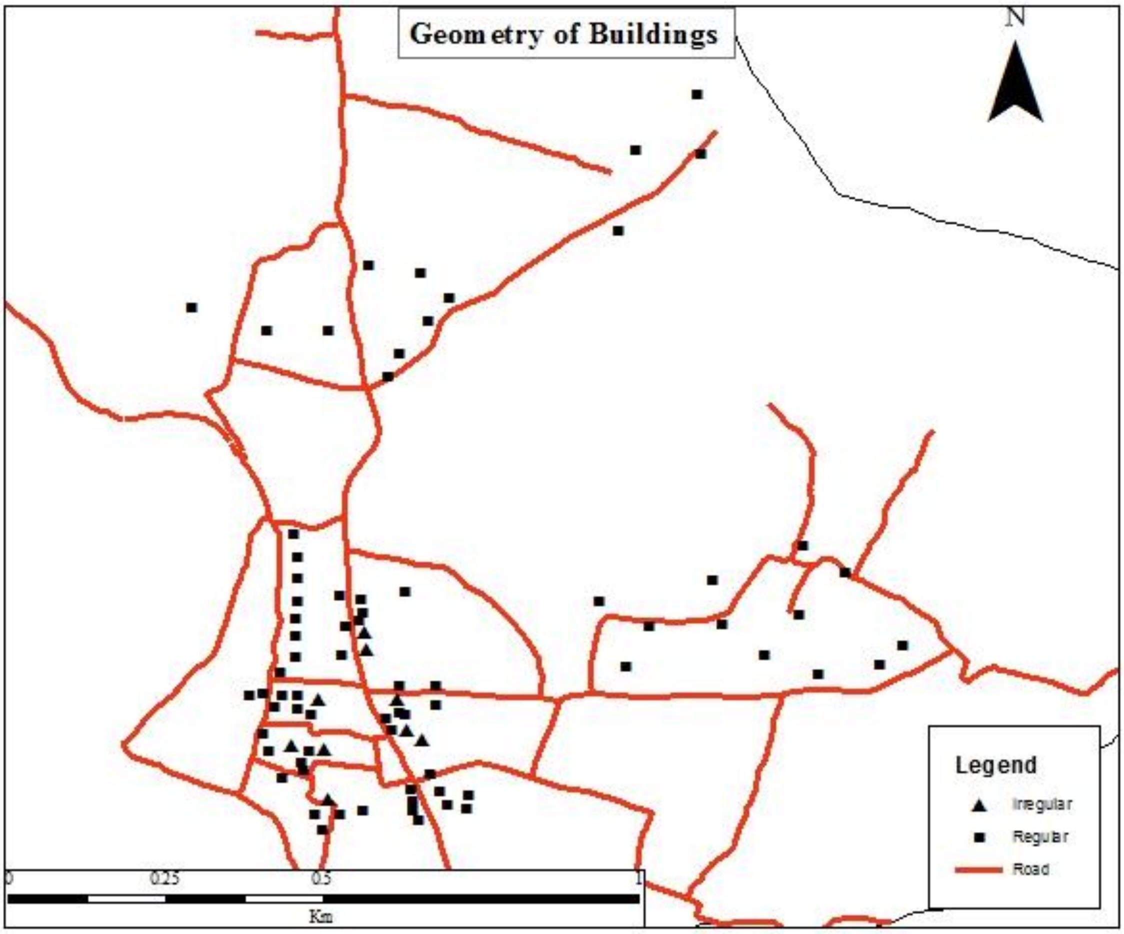


Figure 22. Building type based on Geometry of building



Source: (Thecho, 2008) and Modified fro Field Survey, 2015

Figure 23. Building Geometry

5.9 Past Earthquake events and peoples responses

In Newari culture earthquake is said as "Bhokhya Bo" Literally, "Bhkhya" means Gods and "*bo*" means to fly. People have statues of Gods and Goddess in front of the house in the believe it would control earthquake. While reaching earthquake, they used shout saying ha-

ha-ha so that all people would be aware of earthquake. It is also one indigenes way of telling about occurred earthquake. In Newari ha-ha-ha meant to keep away so they used to say so to keep away earthquake being they themselves strong. They also used to take name of god Narayan and press land by their thumb so that land would not shake.

During earthquake 1990 people stayed in their fields which are available open space by making tent (*Balchha* in Newari) for 2-3 weeks, for making ten straws, straw mat (Suku), bamboo etc were used.

Relief fund were released after 1990 great earthquake by the government. Interview with stakeholder revealed the relief fund was not distributed equally to all suffered family. At that time economic support given by government is distributed by "*Dwarika*". These people who had 2-3 sons, they were not given any economic support because they had lot manpower or human recourses and they can do themselves. But those people who had no sons or only one son or not, they were given economic support for making house. It is found the local people have managed to restore and reconstruct cultural heritage of Thecho

People during the 1990 earthquake, instance response were to settle in nearby open space that generally backyard (*Keba*). Those who were not able to run out of house keep on standing with the suppor to middle wall, pillar or door for their protection.

According to these aged citizens, in the earthquake, 1990 about 100 or 300 people died, 30-40 houses were destroyed in that time most of houses were made by clay, clay bricks and woods, walls system were 18 inch or 24 inch so more houses were not destroyed and 40-50 people were injured, at that time, people had domestic animals (sheeps, goats, cows, buffalos, hens etc). Approximately 100 domestic animals died (including sheeps, goats, cows, buffalos, hens etc) because at that time each of household used to have more than 4-5 goats or sheeps and 2-3 cows or buffalos, 2 main cultural heritage Chua Lachhi and Qua Lachhi were destroyed. They were 3-3 storied but after the earthquaked they were built down into 1-1 storied. Later on when they were re-constructed Chua Lachhi was made again 3 storied whereas Qua Lachhi was made 2 storied.

Now a days, different modern technologies like Alarm are used to give pre-information about calamities, problems, bad news or good news. In the same way at past also for the same purpose "Jhyali and Huge Bells" were used.

CHAPTER: VI

VULNERABILITY ASSESSMENT OF POPULATION, BUILDING AND LIFELINE

6.1 Introduction

Vulnerability is a condition or degree of loss where vulnerability of buildings are resulted by various factors; physical factors (like soil types, slope and fault line) is one side and construction materials, height, age, roofing system, shape(geometry) and separation, socio-economic and cultural aspect also play certain roles. Geological condition, morphological and architectural design as well as level of people's awareness, knowledge and application also play the vital role to building vulnerability.

Vulnerability assessment is the process of estimating the vulnerability to potential disaster hazards of specified elements at risk. Since, different vulnerability assessment models such as HAZUS, RADIUS etc. are developed and in use for assessment of the risk associated with building vulnerability and infrastructures with human causality. RADIUS method has been used to determine damage caused by scenario earthquake and estimation of causalities and other losses in the study area. As Nepal is located in active seismic zone and is potentially prone to earthquake hazard as 92 active faults have been mapped throughout the country by the Seismic Hazard Mapping (EMI, 2005). Thus emergency response plan is essential to avoid this destruction and the estimation of the building damage, population causalities are aid to prepare emergency plan. This study estimated the possible building damage and human casualty based on the two major fault lines earthquake scenario near Thecho VDC (Table 29).

Table 29. Major Fault line around Thecho VDC.

Earthquake Scenario	Fault Name: MCT-3.3/Ms7.6	Fault Name: LH-4.9/Ms6.5
	Distance(Km): 37	Distance(Km): 2.55
	Direction: North	Direction: NorthWest

6.2 North Nuwakot Earthquake Scenario

North Nuwakot earthquake is taken as possible earthquake due to an active fault, MCT-3.3/Ms 7.6, locating 37 Km, North of the Thecho VDC which is the nearest active fault. The possible earthquake scenario is assumed 8 Richter scale and 0.2% PGA.

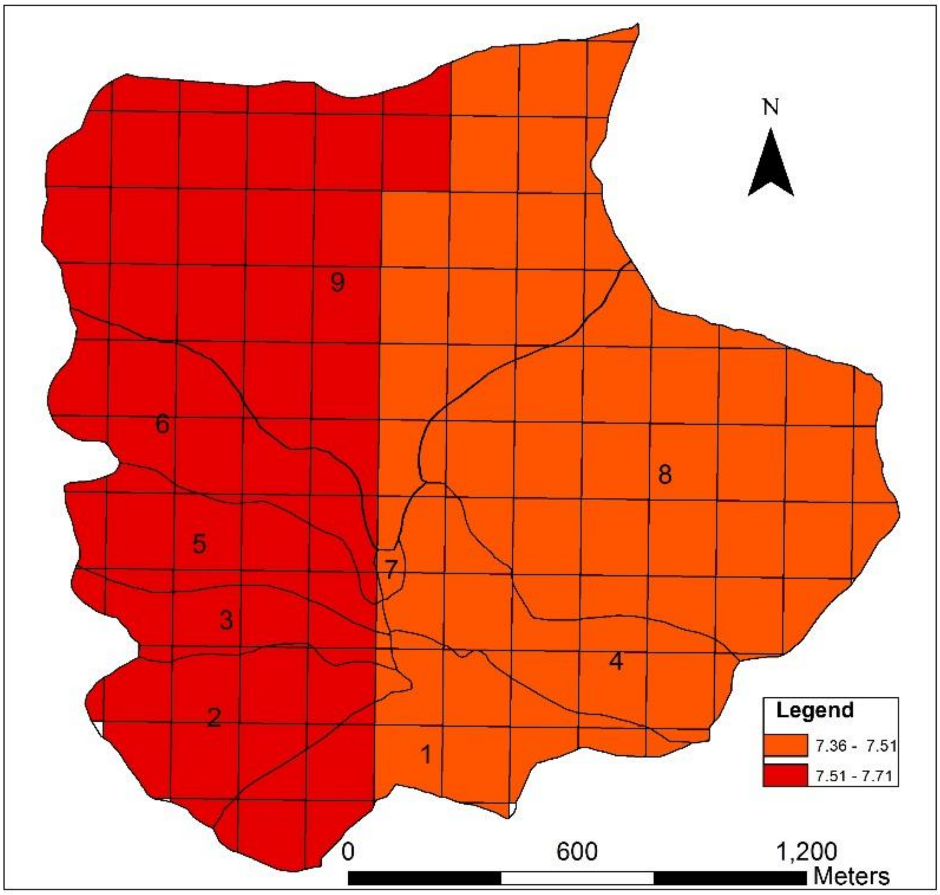


Figure 24.Earthquake Magnitude in North Nuwakot Scenario

North-West earthquake scenario was considered as a possible hypothetical earthquake scenario for this study to estimate the level of building damage, both death and injury during night and day time period. It is expected to occur due to the active fault line MCT which lies north from the Thecho VDC. The magnitude of this fault lies is 7.6 and average depth is considered 20 km.

6.3 Earthquake intensity distribution (MMI)

Modified Mercalli Intensity (MMI) is one of the most widely accepted and used earthquake damage estimation scales. It has evolved based on experiences from observed damaged in the aftermath of earthquake. MMI; scale was developed by Wood and Newman in 1956 for the use in North America (Guragain, 2004). MMI is ground shaking that creates by earthquake during earthquake. It does not shake equal in all place, it depends on geology, soil types, building types and nature. It is assumed that higher the intensity range, higher the shaking level.

6.4 Building Damage Estimation

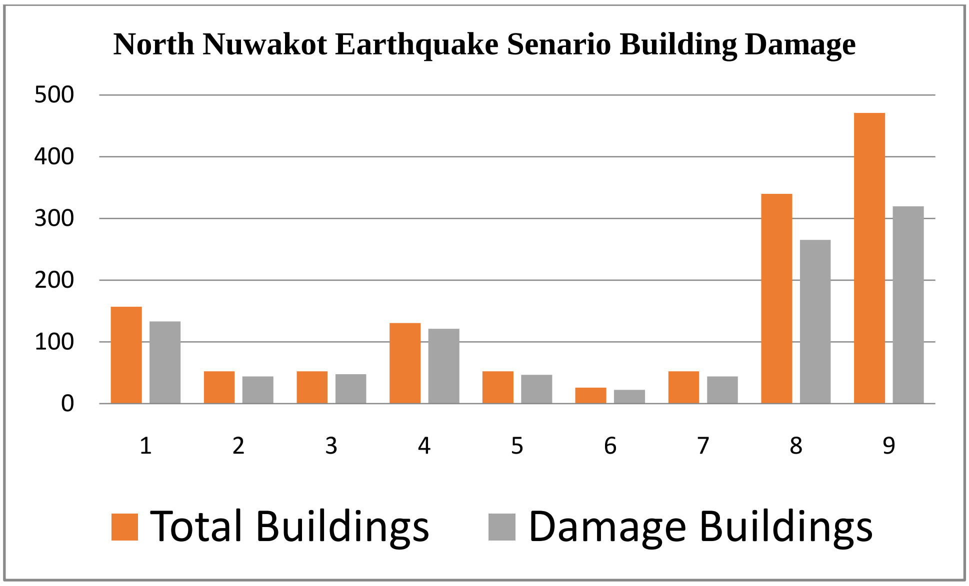
As compared to other VDC, Thecho VDC is small area. The total numbers of buildings in the VDC were 1635 (DRM report, 2015). Out of this, 1280 relatively in 78.3 percent buildings were estimated to be damaged when the North earthquake strikes in the VDC. From 78.0 to 92.4 percent of building are estimated to be damaged in different ward in the study area as illustrated in the table

Table 30.Ward wise distribution of building damage by North Nuwakot Earthquake Scenario and Northwest Khokana Earthquake

Ward No.	Total Buildings	North Nuwakot Earthquake Scenario		Northwest Khokana Earthquake Scenario	
		Damage Buildings	Damage Building %	Damage Buildings	Damage Building %
1	266	133	85	103	65
2	113	44	84	30	57
3	126	48	91	37	71
4	171	121	93	96	73
5	122	47	89	34	66
6	203	22	85	19	72
7	76	44	84	35	66
8	106	265	78	213	63
9	452	320	68	213	45
	1635	1044		779	

Source: Field Survey and RADIUS Analysis, 2013

Compareative description between North Nuwakot and North-West Khokana ie Building damage percent with Nuwakot khakana in ward is only 65% as compared to 84.9 % with North Nuwakot.



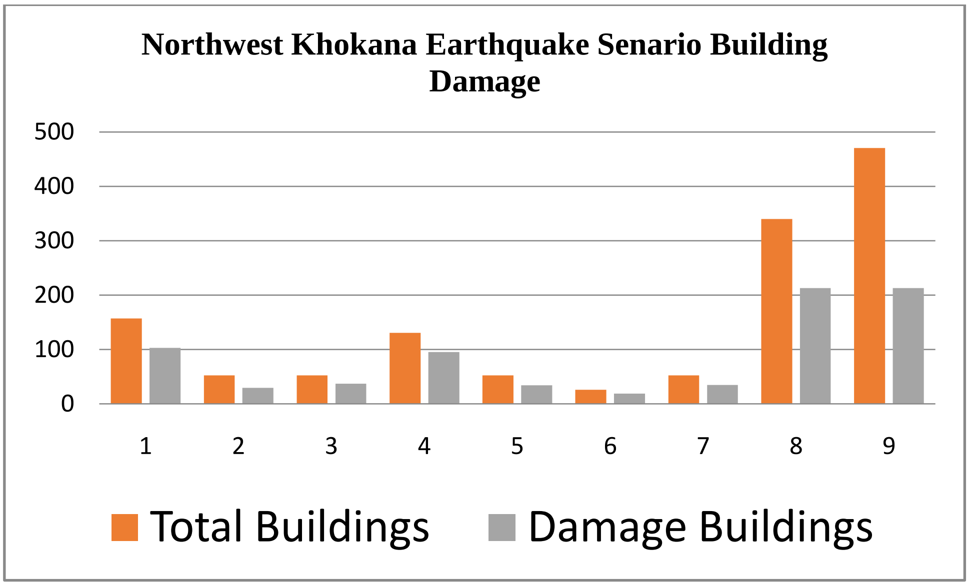
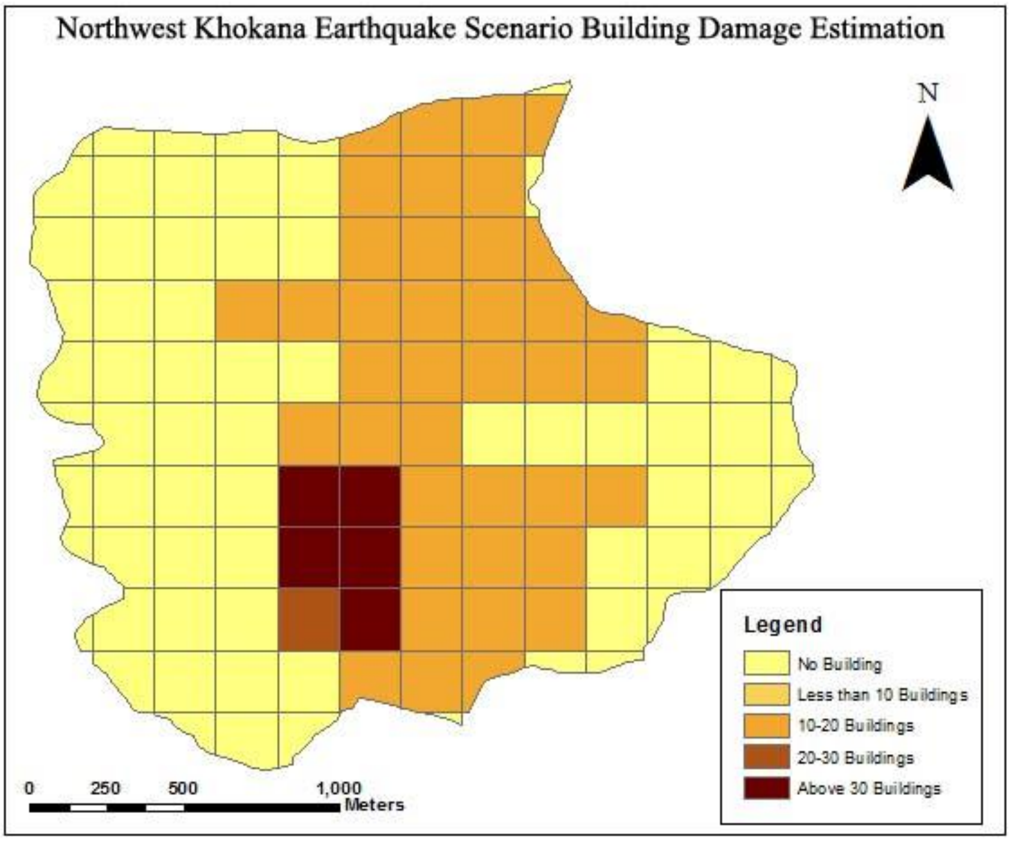


Figure 25. Wardwise Damage Building

As figure shows, though, highest number of buildings are located in ward 9 as it causes larger area of the VDC estimated building damage percentage is lowest in this ward. It is because this ward constitutes most of the new building with RCC construction, whereas highest building damage estimate is found is ward 4 due to presence of older buildings with brick and mud construction.



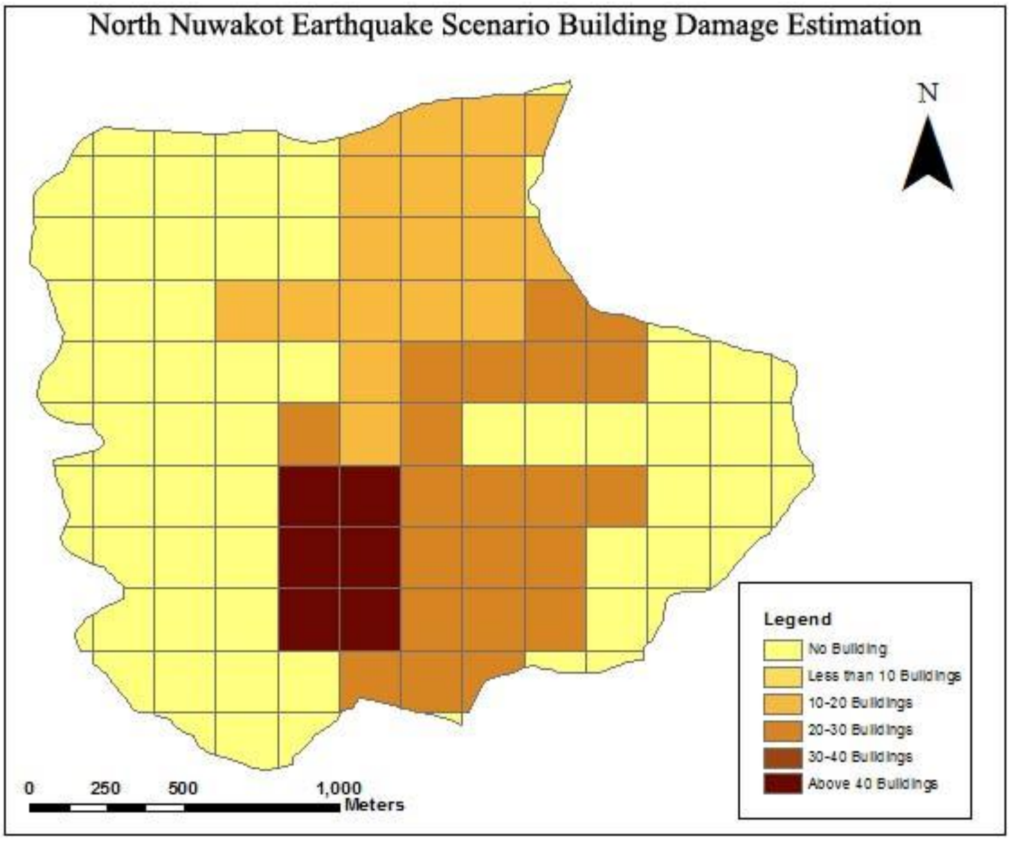


Figure 26. Building Damage Estimations

6.5 Estimation of Causalities

During the earthquake, people's death and injury depends on the damaged and collapsed building. Time is another important factor for the causality. There could be more casualties if the earthquake occurred in night time compare to the day because generally all the family members would go outside for work in day. Since, people stay at home during night; the causalities are estimated in two different time stamp day 2 pm and night 2 am. Table: 23 shows the estimated causalities by North Earthquake during the day time and night time.

The total day population of 5591 have been calculated by RADIUS in the study. Out of the 5591 population in the day time, 51 deaths are estimated and 659 injuries are if the North Earthquake hits the Thecho VDC. Among different wards, highest number of injured and death people is estimated in ward 9. On the other hand, the lowest death and injury were in ward number 6. Similarly, the total night population of 10086 have been calculated in RADIUS in the study area. Among this population, 1414 and 116 people are highest number of likely injury and death.

Table 31. Casualties by North Nuwakot Earthquake during Day and Night (2 am and 2 pm).

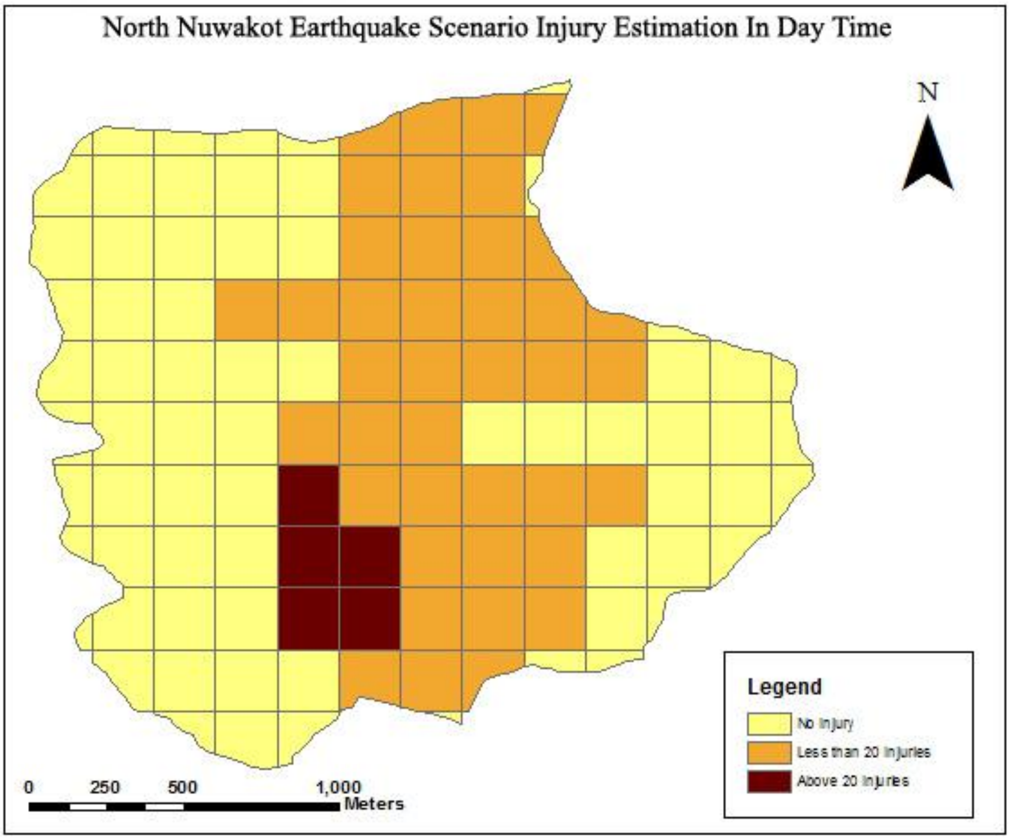
Ward No	North Nuwakot EQ Scenario						North West Khokana EQ Scenario					
	Day Time			Night Time			Day Time			Night Time		
	Day population	Death	Injury	Night population	Death	Injury	Day Population	Death	Injury	Night Population	Death	injury
1	475	6	66	924	14	157	475	2	28	924	4	67
2	173	3	31	346	6	79	173	1	12	346	2	29
3	115	2	22	230	5	55	115	1	9	230	1	24
4	378	5	70	504	11	124	378	2	31	504	3	56
5	136	3	27	272	8	67	136	1	11	272	3	28
6	71	1	7	141	2	17	71	0	3	141	1	9
7	154	2	19	309	4	48	154	0	8	309	1	21
8	1486	13	149	2446	27	264	1486	4	65	2446	8	118
9	2603	17	268	4914	39	603	2603	4	101	4914	9	218
Total	5591	51	659	10086	116	1414	5591	14	269	10086	32	568

Source: Field survey and RADIUS Analysis, 2015

The total day population have been calculated by RADIUS in the study area is 5591. Out of the 5591 population in the day time, 51 people were found death and 659 people were injured when the North Earthquake hits the Thecho VDC. Among different wards, highest number of injured and death people were found in ward 9. On the other hand, the lowest death and injury were in ward number 6. Similarly, the total night population have been calculated in RADIUS in the study area is 10086. Among this population, 1414 and 116 people are highest number of likely injured and death.

North-West Earthquake Scenario was considered as a possible hypothetical earthquake. Earthquake occurrence time is more important for the causality estimation and people's death and injury depends on the damaged and collapsed building. If earthquake occurred in night time compare to the day, there could be more casualties because all the family members would go outside for work in day since, people live home during in night so the occurrence time of this earthquake considered two different time such as day 2 pm and night 2 am. Table 23 shows that the estimated causalities.

The total day population generated by the RADIUS in the study area was 5591 and night population was 10086. Out of total day population, 269 populations estimated injured and 14 estimated death population when the North-West Earthquake occurred in the day time. During the day time, when earthquake occurred, the number of people injury emerged highest in ward number 9 which is 101 people and highest death people were emerged in ward number 9 and 8 which 4 person. Similarly, 568 populations estimated injured and 32 estimated death population from night population. Where ward number 9 possess the high number of death and injuries than other ward which respectively 9 person and 218 person.



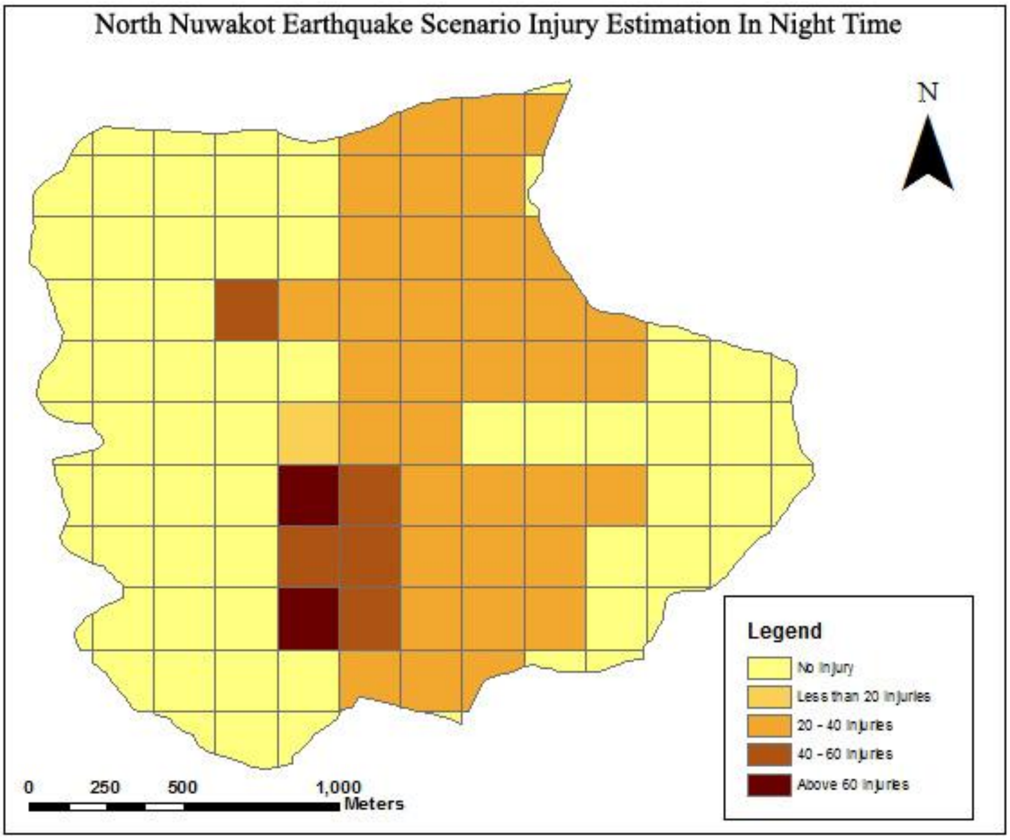


Figure 27. Human Injury North Nuwakot Earthquake Scenario

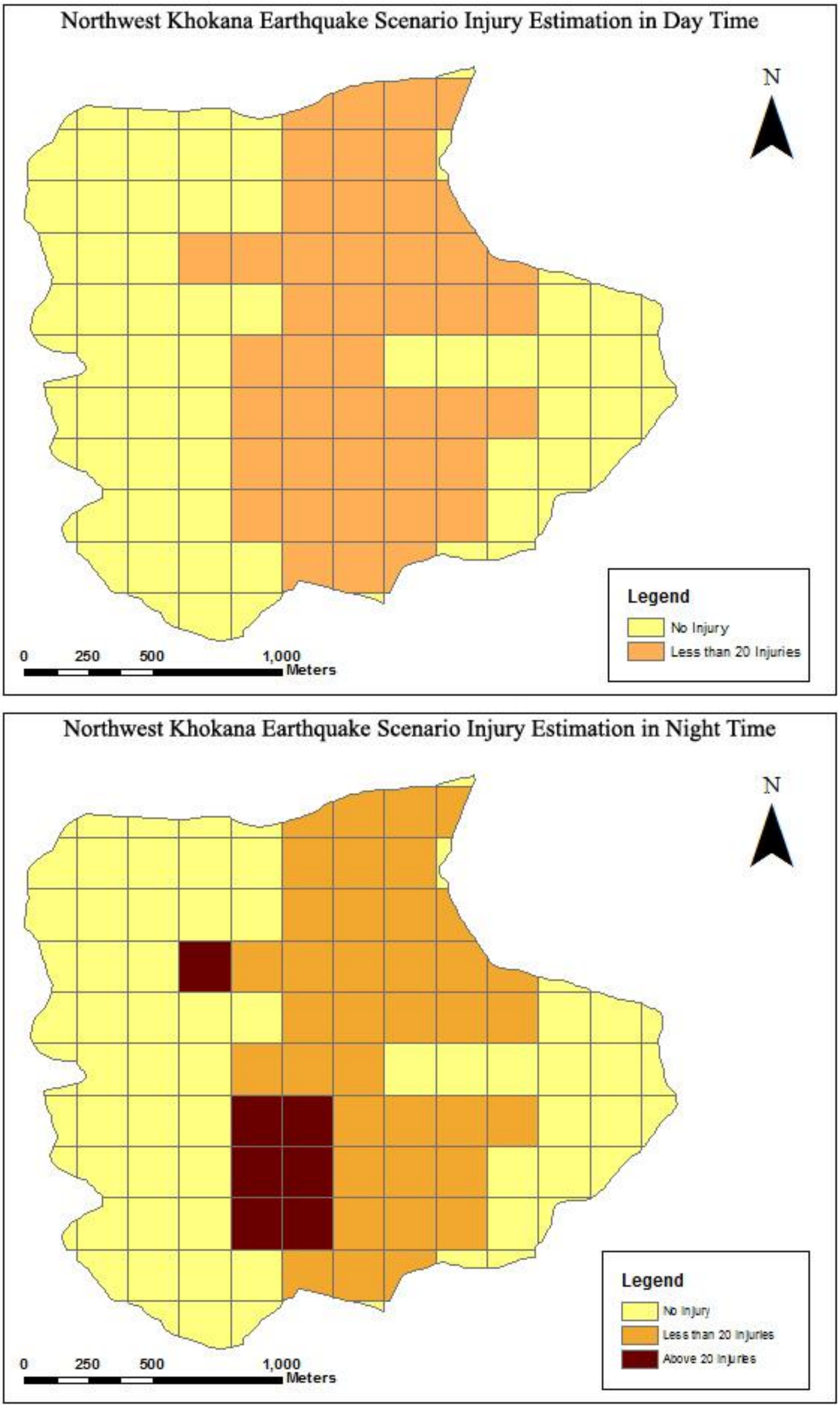
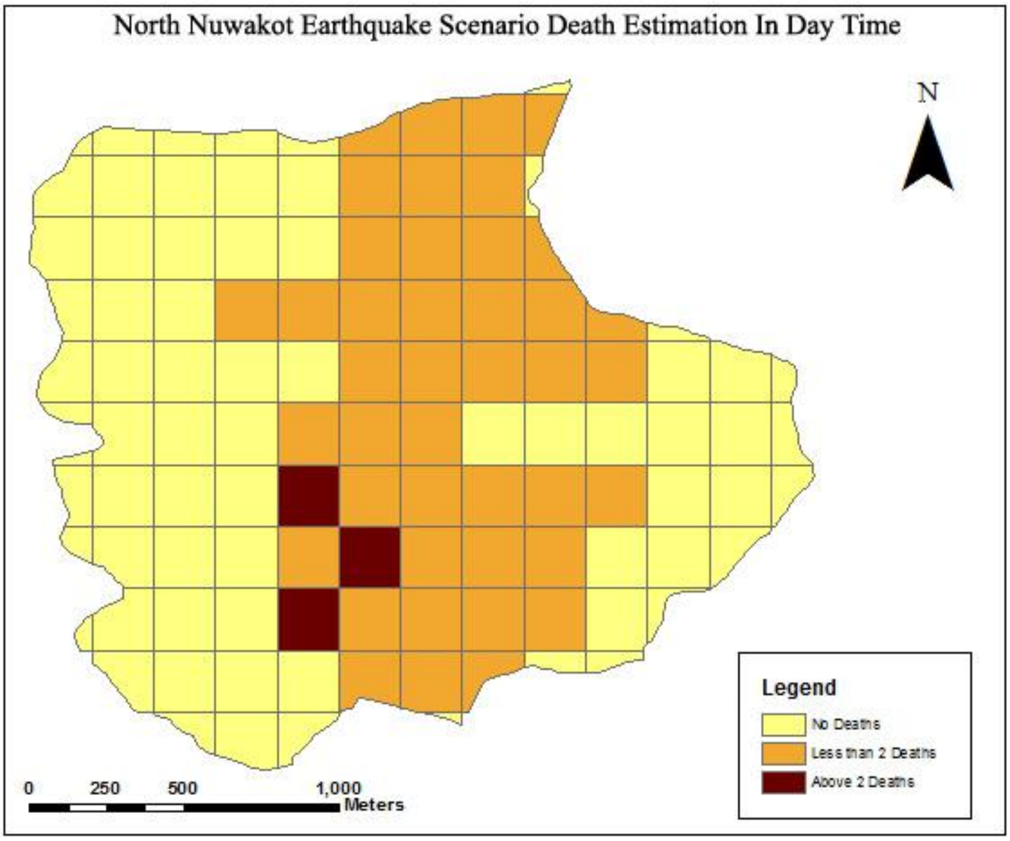


Figure 28. Human Injury Northwest Khokana Earthquake Scenario



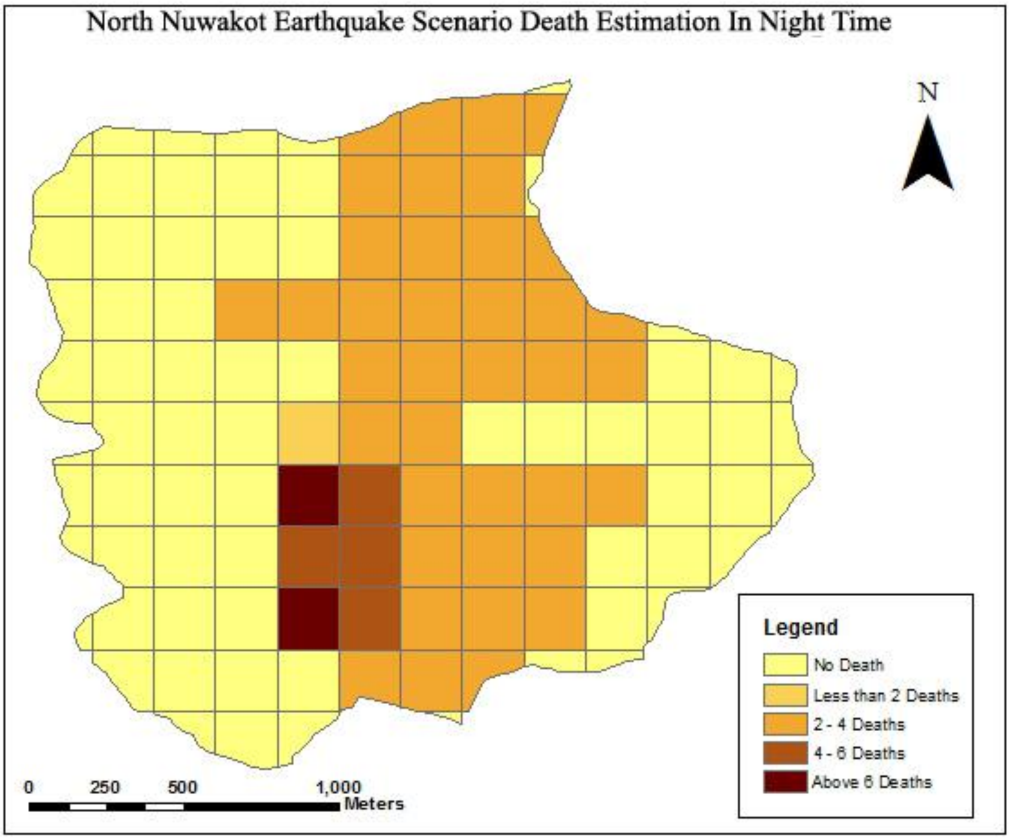
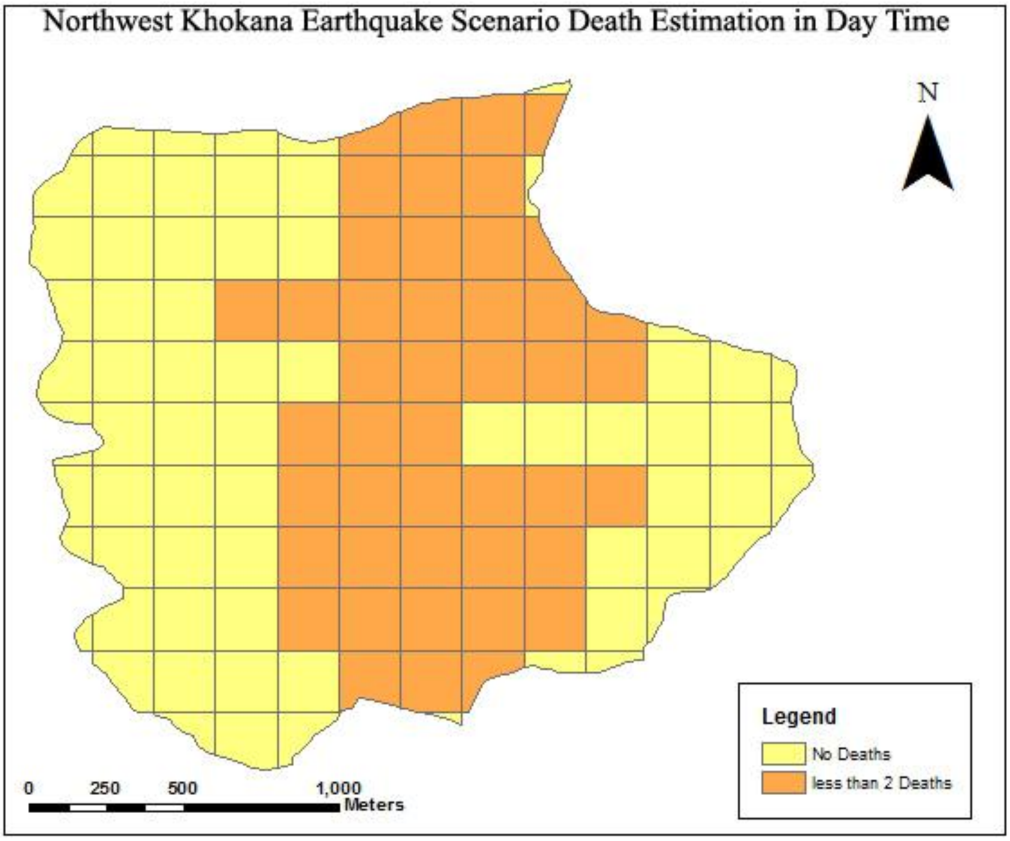


Figure 29. Human Death in North Earthquake Scenario



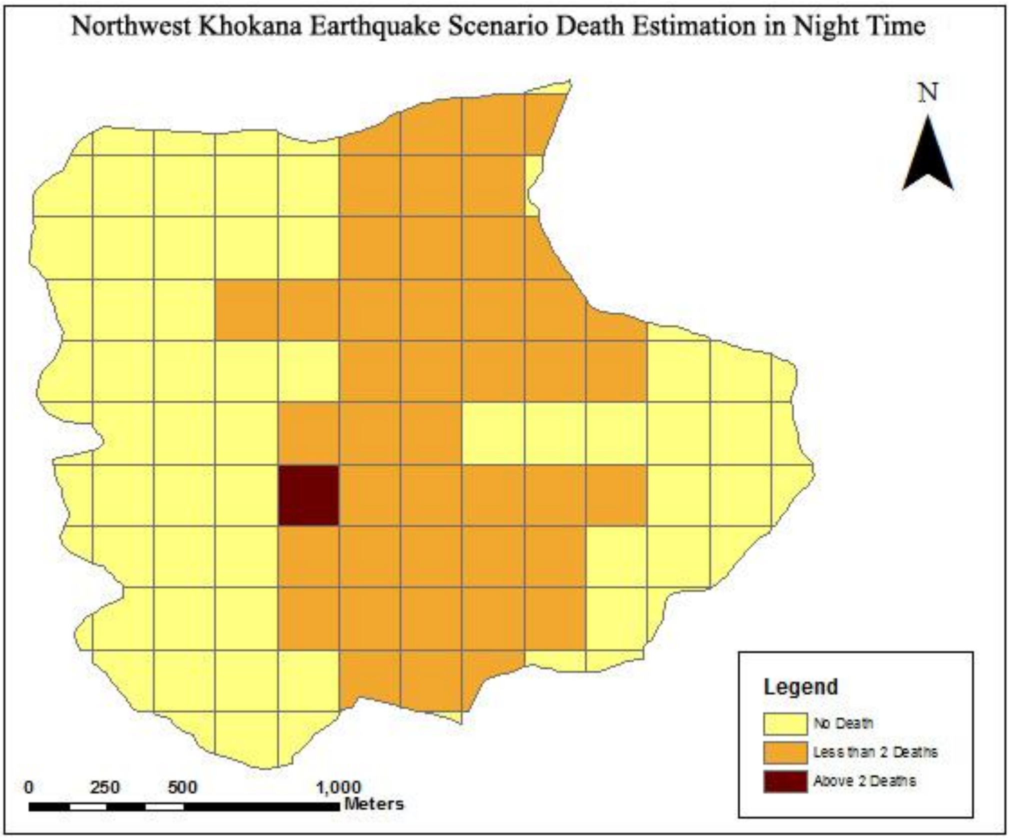


Figure 30. Human Death in Northwest Khokana Earthquake Scenario

6.6 Lifeline Inventory and Damage

“Lifeline”, the term denotes those types of facilities which are necessary for the effective functioning and wellbeing of any society (Chaudhari, 2008). Lifelines are the essential physical structure that need for the people and community. There is direct relationship between human and these facilities such as road, bridge, electricity, telecommunication cannel, pipeline, water tank, and tower etc. This table no. 24 shows the existing lifelines and its damage ration if the North Earthquake strike the Thecho VDC.

Table 32. Inventory and Damage by North Earthquake

Lifeline	Note	Total Count	Damage Number	Unit	Damage Ratio (%)
Road 1	Length of Local Roads (in km)	6	0.2	km	3.6
Road 2	Length of major roads such as Freeways/ Highways (in km)	6	0.1	km	2.1
Electric1	Number of major Electrical & Telecommunication transmission towers	5	0.1	Count	2.0
Electric2	Number of Electrical & Telecommunication sub-stations	1	0.2	Site	15.2
Water 1	Length of major Water & Sewage trunk and distribution lines (km)	4	0.1	km	1.3

Source: Field Survey and RADIUS Analysis, 2015

The table shows the level of lifelines damage ration in North Earthquake scenario with the magnitude of 7.6 Richter scale. The to result produced from RADIUS estimated that most of the local roads, major road, electrical and telecommunication transmission, sub-stations and major water and sewage trunk will be damaged in the ratio 3.6, 2.1, 2, 15.2 and 1.3 percent approximately. This level of damage could hamper the people accessibility. People wouldn’t able to move from one place to other because of damaged of roads network and electric and telecommunication tower.

6.7 North-west Khokana Earthquake Scenario

North-West earthquake scenario was considered as a possible hypothetical earthquake scenario for this study to estimate the level of building damage, both death and injury during night and day time period. It is expected to occur due to the active fault line MCT which lies north from the Thecho VDC. The magnitude of this fault lies is 7.6 and average depth is considered 20 km.

6.8 Building Damage Estimation

Out of the total 1635 building in the study area, around 955 (58.4 percent) building were estimated to be damaged when the North-West Earthquake strikes in the Thecho VDC. In total 45.3 percent (lowest) to 73.1 percent (highest) of building are estimated to damage in different wards. The ward number 4 and 6 represent highest number of building likely to be damage and the ward number 2 possesses the less number of building likely to be damaged. Ward wise total buildings, possibilities damage building number and damage percent are shown in table 22as well in graph below.

6.9 Estimation of causalities

North-West Earthquake Scenario was considered as a possible hypothetical earthquake. Earthquake occurrence time is more important for the causality estimation and people's death and injury depends on the damaged and collapsed building. If earthquake occurred in night time compare to the day, there could be more casualties.

The total day population generated by the RADIUS in the study area was 5591 and night population was 10086. Out of total day population, 269 populations estimated injured and 14 estimated death population when the North-West Earthquake occurred in the day time. During the day time, when earthquake occurred, the number of people injury estimated highest in ward number 9 which is 101 people and highest death people were estimated in ward number 9 and 8 which 4 person. Similarly, 568 populations estimated injured and 32 estimated death population from night population. Where ward number 9 possess the high number of death and injuries than other ward which respectively 9 person and 218 person.

6.10 Lifelines inventory and Damage

Table 33.Lifelines and Damage by North-West Earthquake Scenario

Lifeline	Note	Total count	Damage Number	Unit	Damage Ratio (%)
Road1	Length of Local Roads (in km)	6	0.1	km	1.4
Road2	Length of major roads such as Freeways/ Highways (in km)	6	0.1	km	0.9
Electric1	Number of major Electrical & Telecommunication transmission towers	5	0.0	Count	1.0
Electric2	Number of Electrical & Telecommunication sub-stations	1	0.1	Site	8.5
Water1	Length of major Water & Sewage trunk and distribution lines (km)	4	0.0	km	0.5

Source: Field Survey and RADIUS Analysis, 2015

According to result calculated from RADIUS, it is estimated that some of the electrical and telecommunication sub-station, water line, major transportation and local road will be damage with the magnitude of 6.5 Richter scale with 2.55 km distance. If the North-West Earthquake scenario hits in the study area, damage is estimated in the ratio of 0.1 percent, as compared to the damage to lifelines by North- Earthquake scenario the North-West Earthquake scenario, North West Earthquake is in some way moderate.

6.11 Estimated outcomes (Results) from the two different Earthquake scenarios

In the study area, two different earthquake scenarios have been used in RADIUS Program and estimated the damage on building, lifelines as well as population causalities. Main Central Thrust and Lesser Himalaya two fault lines were taken to measure the vulnerability on buildings and lifelines. Where, we can found the different predictable result from these two scenarios which is discussed below.

Expected result from the North Earthquake scenario, name of the fault line isMCT-3.3/Ms7.6

- Out of the 1635 buildings (Thecho, 2015)in the VDC, 1280 (78.3 percent) building were found likely to be damaged, if the North Earthquake hits the VDC.
- Damages on lifelines in the North Earthquake Scenario is estimated that damage percent of the local roads, major road, electrical and telecommunication transmission, Telecommunication sub-stations and major water and sewage trunk are 3.6, 2.1, 2, 15.2 and 1.3 percent respectively.
- Out of the total population 5591, causalities in the North Earthquake scenario is estimated that 51 people were found death and 659 people were injured.
- Out of the total population 10086, causalities in the North Earthquake scenario is estimated that 116 people were found death and 1414 people were found injured
- The highest number of injured and death people were found in ward number 9 which were 268 people and 17people respectively in day time and 603 people(injury) and 39(death) people were found in Night time.
- The lowest number of injured and death people were found in ward number 6 which were 7 people and 1 people in day time and 17 people and 2 people in night time respectively.

Expected result from North-West Earthquake scenario, name of the fault line is LH-4.9/Ms6.5

- Out of the 1635 building (Thecho, 2015) and CBS profile) in the VDC, 955 (58.4 percent) building have been found damage, if the North-West Earthquake Scenario.
- Damage percent of lifelines, local roads, major roads, major electrical and Telecommunication transmission sub-stations in North-West Earthquake scenario are same i.e 0.1 percent.
- Out of the total population 5591, causalities in the North-West Earthquake scenario is estimated that 269 people were found injured and 14 people were found death in day time and at night time, the total population is 10086, where 568 people were found injured and 32 people were death.

The study revealed that there is the risk of the loss of 51 to 116 lives, 659 to 141 person serious and moderated injury in North Nuwoakot earthquake scenario and 14 to 32 lives loss and 269 to 568 person were serious and moderated injury in North-West Khokana earthquake scenario 58.4 % to 78 % damage of building which will make 955 to 1280 people will homeless if the earthquake strike in the nearest earthquake fault line North Nuwakot and North-West Khokana. It means that necessity of first aid trained and rescue and medicinal first response team to reduce the impact as well as the open space for emergency settlement with minimum facility of tent, drinking water, food and health and psychosocial counselor to reduce trauma in later days. Awareness of people and capacity building up of existing human resource and generation of human resource for emergency response in possible earthquake for rescue and medical care is seems inevitable.

Table 34. Expected damage from nearest earthquake fault

S.N	Expected results	N-Nuwakot EQ	NW-Khokana EQ
1	Building Damage	1280	955
2	Lifeline damage (i)Local road	3.6	0.1
3	Lifeline damage (ii)Major road	2.1	0.1
4	Lifeline damage (iii)Electricity	2	0.1
5	Lifeline damage (iv)Telecommunication transmission	15.2	0.1
6	Lifeline damage (v)Telecommunication sub station	1.3	0.1
7	Day time death	51	14
8	Night time death	116	32
9	Day time injury	659	269
10	Night time injury	1414	569
11	Mostly effected ward	Ward no. 9 was expected to have highest death	Ward no. 9 was expected to have highest heath

North Earthquake Scenario is more hazardous than the North-West Earthquake scenario. The estimated people causalities, building and lifelines damage percent have been found more in the North Earthquake scenario and North-West Earthquake Scenario is moderate where compare the level of damage to lifelines North- Earthquake scenario with the North-West Earthquake scenario.

The emerged of damage to a building during an earthquake depends not only on the magnitude of the earthquake, but also on the geology of study area, building configuration, quality of design and construction (IIT, 2007). Likewise, Population density, fault line direction etc. also plays hummers role to affection the building and lifelines vulnerability.

6.12 Gorkha Earthquake scenario 2015 April 25

Devastating great earthquake of magnitude of 7.6 hit Nepal on 2015 April 25 epicenter at Barpaka, Gorkha occoured at 11:56 AM (National Seismological Center of Nepal, 2016). Geographically it was located at 28.24 ° northing and 84.75 ° easting with the depth of 11 km in main central thrust fault line. This place is 85 km northeast from the study area.

There are hundreds of aftershock after this shock with magnitude up to 6.8 in Dolkha 12th May 2015.

Losses caused by this earthquake have assessed by the government of Nepal (PDNA, 2015).

Table 35. Losses caused by 25th April 2015 Earthquake in Nepal

Lives losses	8790
Injury	22,900
Private Building damage	4,98,852
Government building	2,656
School Rooms	19,000

Due to this shock and consequesnt series of after shocks Thecho had lost large numbers of building, few lives.

Table 36. Summarized socio-economic losses in Thecho VDC.

S.N	Loses	Numbers
1	Death	2
2	Injury	0
3	Building Damages	
	Full	634
	Half	212
	Partial	21

With the hypothesis run of building damage, injury and death in RADIUS with earthquake scenario of 25th April 2015 postulated following details.

Table 37. Socio-economic losses estimated by the RADIUS on 25th April 2015 Earthquake Scenario

Ward no.	Building Damages	Injuries	Death
1	77	7	0
2	17	2	0
3	28	2	0
4	74	7	0
5	24	2	0
6	16	1	0
7	27	2	0
8	171	16	1
9	127	17	1
Total	560	56	2

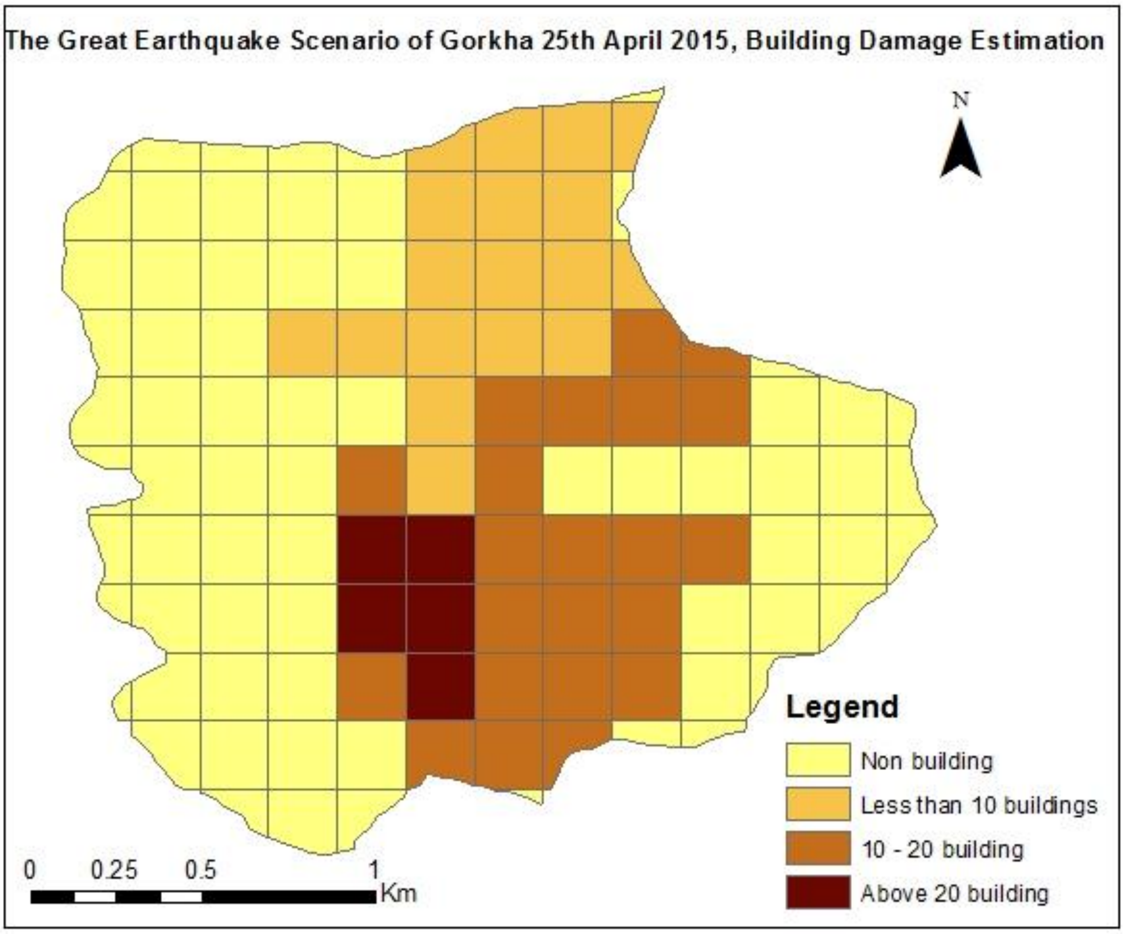


Figure 31. Building Damage estimation on the great earthquake scenario 25th April 2015, Gorkha

Actual building damage estimated by RADIUS is lower than the actual post earthquake assessment of Thecho and other earthquake scenario of nearest two active fault lines of Khokana and Nuwakot. In case of actual damage caused by 25th April 2015 and modulated damaged from RADIUS, real damage caused is found higher. It is revealed that additional damaged were made by aftershock.

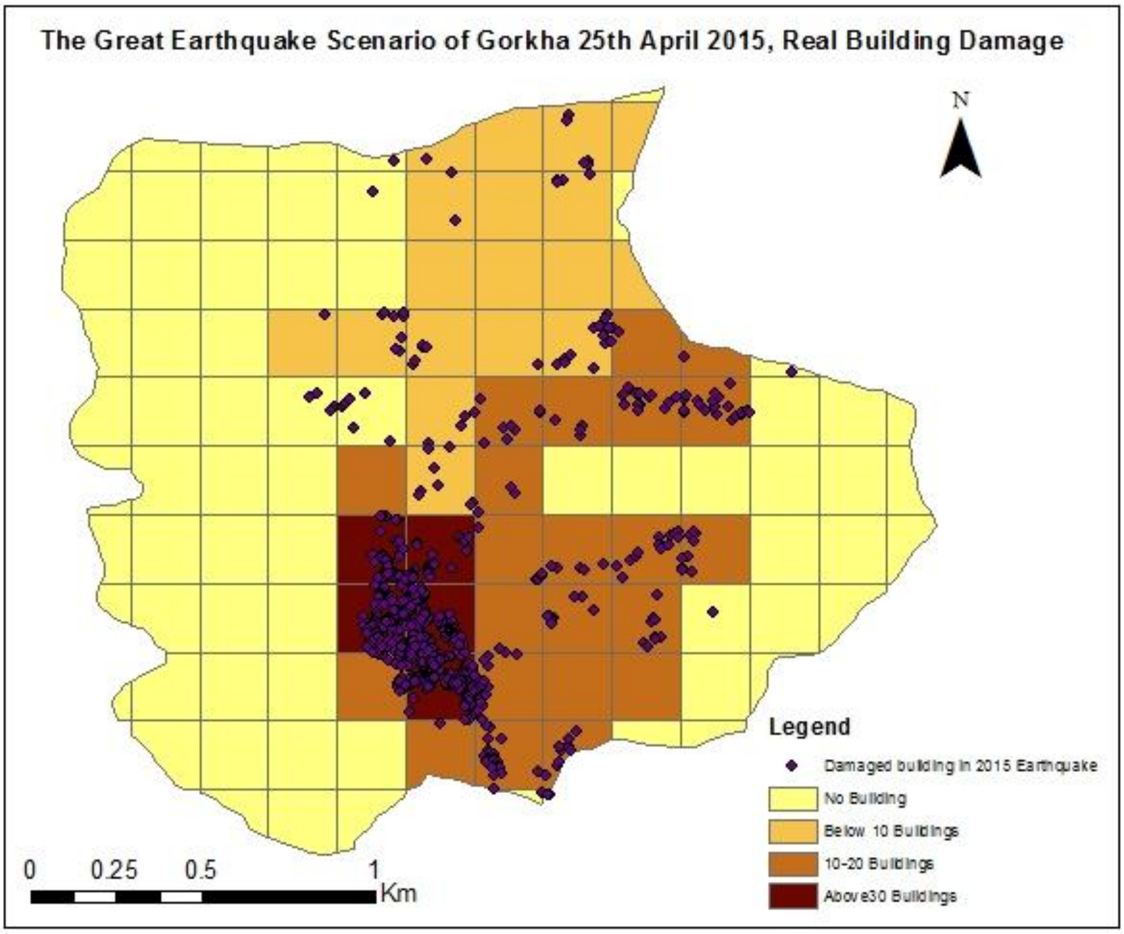


Figure 32. Real Building damage in 2015April 25

About the risk of damage of building estimated by the RADIUS is found much closer to the actual damaged caused by the 25th April 2015 earthquake. It proves that RADIUS method and tool reliable and valid tool for the building damage estimation caused by the earthquake. Spatial location of building damaged by 25th April, 2015 Earthquake is found coincide with hypothetical earthquake scenario run by RADIUS on all three scenario; North Nuwakot, Northwest Khokana and Barpak, Gorkha.

CHAPTER VII

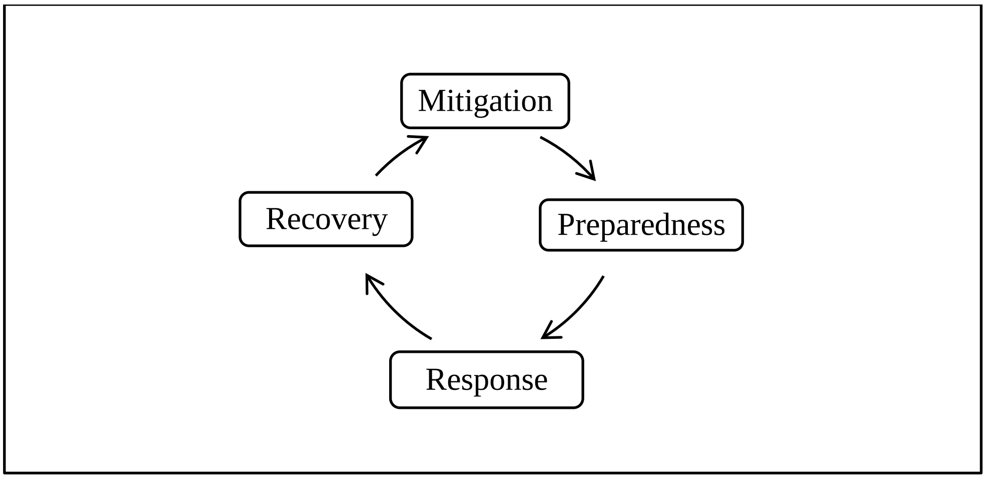
INVESTIGATION OF EMERGENCY RESPONSE PLAN AND PULBIC AWARENESS AND PREPREADNES

7.1 Emergency Response Plan

Emergency is that fearful condition where emergency steps should be taken for protecting property and people manage emergency step helps not to change natural disasters or disastrous event. Such pre-managed work plan and organization preparedness comes under emergency management which mobilizes organizational capability and government, non-government, self- service private sectors, capabilities and helps are significant to direct necessary co-ordination and co-operation emergences in skillful way

Disaster reaction focus in current and temporary need and sometimes at can be termed as disaster support. It's difficult to have clear distinction between pre-activity stage and beneficial stage by pre-activity stage. Some pre-activities mobility like management of temporary settlement or drinking water supply etc. may extend to beneficial stage (Dharan, 2070).

Before the disaster, when preparedness and mitigation are important, immediately after the disaster when the emergency response capability is depended on and after the disaster when the city's capability to recover in short time form the disaster is most important.



Source:-Seismic Risk Management of Kathmandu Valley, 2002, Pp 32

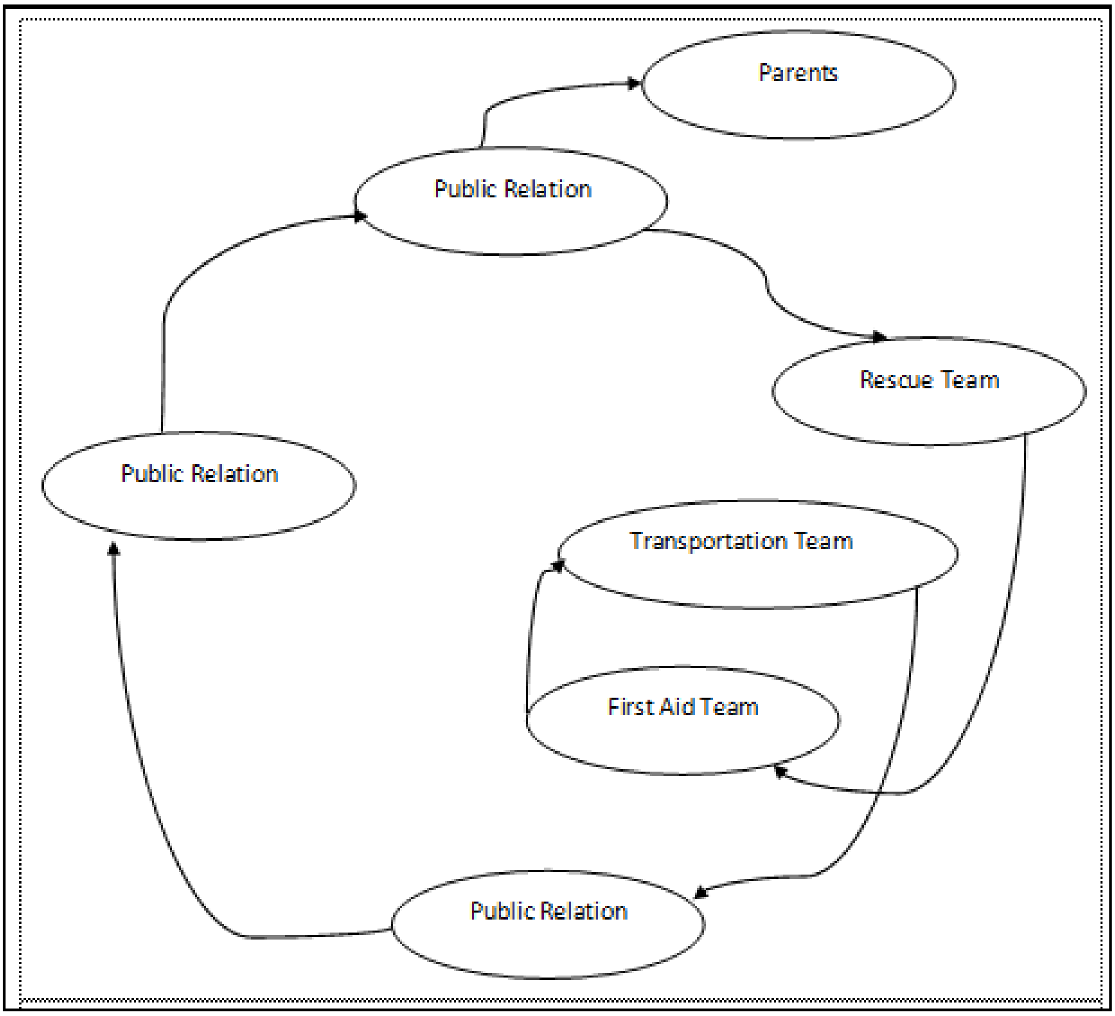
Figure 33. Preparedness and mitigation cycle

In Nepal Kathmandu valley Earthquake Risk Management Project (KVERMP) was implemented jointly by National Society for Earthquake Technology (NSET-Nepal) included one of the project component is a school earthquake safety program of KVERMP. The project aimed to improve the situation and start a process toward managing the earthquake risk in the valley.

Emergency response plans need to be still framed at the levels starting from the national level to the local level. Now a day, most of organization have emergency response plan. Schools play a vital role in every community. Schools teach civics, education citizens of their rights and duties. In the schools, students learn the lessons of history, the discoveries of science and the rewards of publics serves. In the study area the two schools have Emergency Response Plans. Earthquake threatened communities need earthquake-resistant school. When schools are closed because of earthquake damage, education is delayed and community life disrupted. Repair and construction of school building are difficult and expensive after an earthquake, their grounds can be used for temporary shelter and emergency response centers. Where school attendance is compulsory, communities have a moral obligation to provide a safe study and work environment. But most important, earthquake-threatened communities need earthquake-resistant school to protect their teachers and children. These are the main goal of School Earthquake Safety Program. In study area this programs is also going on according to the School Earthquake Safety Program. The structure below is the of Earthquake response plan of Saraswoti Higher Secondary School.

If earthquake occurs, every class teacher will inform to the public relation team (Head Teacher). Public relation team will inform to the rescue team. Then rescue team will go to class room and rescue the injured students. Rescue teams are responsible to handing injured students to First Aid Team which further check for type of injury either normal or serious. Seriously injured will be admitted to nearby health post or hospital. Class teacher will supervise all this activities. Class teacher will inform to Public Service team. Public Service team will be in touch with Parents

Chart of Earthquake Response Plan of Saraswoti High Secondary School, Thecho-Lalitpur



Source: (Bhattrai, 2015)

Figure 34. Chart of Earthquake Response Plan of Saraswoti High Secondary School, Thecho-Lalitpur

Disaster Plan of Schools

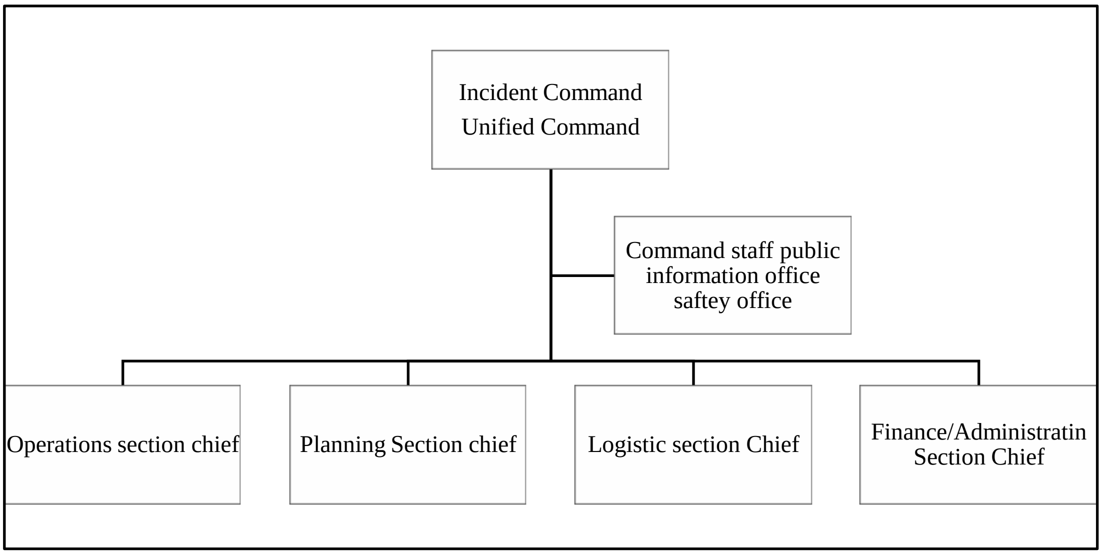
In the study area there are 14 cooperative organizations, 9 school 7 Guthi 5 clubs a health post, a Telecom, an Electricity Authority, and DRM. But only two schools have making evacuation site which are a parts of earthquake preparedness and response plan (Marashin, Shrestha, Dhungel, & Joshi, 2067).

Figure 35. Evacuation site of Shree Saraswoti Secondary High School

Figure 36. Evacuation site of Baal Ankur School

It has been almost 15 years that the earthquake awareness program was continuously going on through NSET-Nepal but the effect of this could not be seen as more among schools and communities. Now at present Red Cross Society also has been helping to organize earthquake awareness program (SHSS, 2015).

Every institutions and Organization should have earthquake emergency response plan. Earthquake response team preliminary include Evacuation, Operation, Logistic Team and Communication Team (Jimee, DPER Director: Personal Communication, 2015) . This team possesses the capability to mitigate possible loss of life and property in any kind of disaster.



Source: NIMS Incident Command System Field Guide, 2011 Second edition, Jeft Jones, Division Chief.

Figure 37. Sample Command and general Staff Organizational Chart

Most of the Organization followed NIMS Incident Command System Field Guide (2011) when they held Earthquake Response Plan in which Incident Command Unified command at the top after that, there is command staff public information office Safety office. Inside the incident command unified command there are four different departments (Jimee, DPER Director: Personal Communication, 2015). They are Operations section chief, Planning section chief, Logistic section chief and finance/Administration section chief.

7.2 Public Awareness and Preparedness

Nepal, multiple hazardous countries, has faced lots of small and large hazards condition. It is situated in the seismicity active Himalayan mountain belt. Historical record of the past earthquake was 1255, but most destructive earthquake stroke in 1934, its magnitude is 8.4, which did greatest damage in Kathmandu Valley.

Generally, earthquake is taken as a sudden and violent shaking that strike without warning and may cause a large amount of losses even in very short period. So it may not be stopped but effort can be made to reduce the impact of disaster (Pokharel, 2004). Even it is beyond human control, knowledge, awareness and preparedness plays vital role in reducing earthquake risk.

Awareness is the knowledge and consciousness of people to reduce risk and possible earthquake (Jimee, 2006). It is a part of the capacity that prepares potential victim to cope with the possible impact of an earthquake.

During in the past 20 years the Nepalese government has formulated a number of natural disaster preparedness, plans, programs and act (NDRMP, 2005). Existing disaster management activities in the country is not effective. In this context, people's knowledge, awareness and preparedness are most valuable for reducing earthquake vulnerability. In the study area, residential household and key informants survey were use to know the people awareness and preparedness level.

7.2.1 Knowledge and Awareness of Earthquake

To know the level of knowledge and awareness in the Thecho VDC, 83 residential household and 24 key informants were choose for interview. In the VDC, many people are aware of earthquake through radio, FM, television and other communication sources. In the household survey and KIS found that only DRM and Red Cross Society have conducted awareness programs of earthquake in this current years by Street dram, showing video but according to view of respondents, those programs are not sufficient.

Table 38. Knowledge and Awareness of Earthquake Respondents

Information from Media		Knowledge of Earthquake		Know about Jhatpat Jhola, Drop cover and hold		Participation		Living Risk		Knowledge and Awareness level
Yes	No	Yes	No	Yes	No	Yes	No	Yes	No	Answer
71	12	68	15	67	16	63	20	61	22	Respondents
85.54	14.46	80.72	19.28	80.72	19.28	75.90	24.10	73.49	26.51	Percent

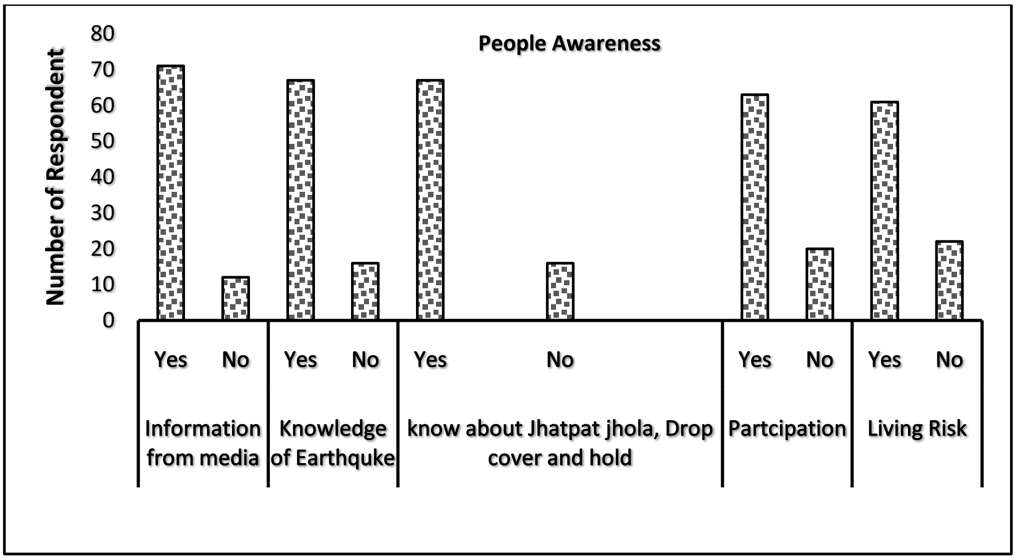


Figure 38. Earthquake Awareness

During the field survey it was found that 85.54 percent respondent get information about earthquake from Media (T V, Radio, F M). Although the person says that they did not take it seriously. They have certain level of knowledge about an earthquake but, most of the people did not know the institution and organization for getting help in case of earthquake disaster. Out of the total respondent only 19.28 percent were get aware information about earthquake from media. Similarly, 73.49 percent respondent feel living risk because their buildings are not strong, not used earthquake safety methods and building were olds and 26.51 percent people's answer were they were not feel to live in risk. In the study area, DRM, VDC, Red Cross Society was held the awareness program of earthquake. In that program, only 24.10 percent people had participation. From media and Street Dram, video, 80.72 percent people know about Jhatpt Jhola and Drop Cover and Hold but they had not applied it in their daily life. Out of the total people, 19.28 percent people had not heard about Jhatpat Jhola, Drop Cover and Hold.

7.2.2 Level of Preparedness of Earthquake

Capacity of wise reaction during earthquake by local people, their future planning concentrating on the urgent needs and their self consciousness about earthquake, together can be perceived as preparedness of earthquake. It depends on people's knowledge, perception and awareness level. Preparedness is important as it plays the vital role for reducing the earthquake vulnerability.

During the field survey some questions were asked to respondent to know the level of preparedness in the study area which is discussed below.

People response when during an earthquake

Table 39. People response to earthquake

Act during an Earthquake	Number of Respondent	Percent
go at open place	43	51.81
Run always	16	19.28
Under table	20	24.10
Shouting	4	4.82
Total	83	100

Source, Field Survey, 2015

To know about the people's perceptions on earthquake in the study area some questioned were asked to assess how to react during an earthquake by local people. Most of the people were get familiar about earthquake disaster although, very few were aware the things that necessary to act during an earthquake. During the field survey it was found that about 51.81 people would go to the open place. Similarly 19.28 percent people would run away from the house, 24.10 people were shouting (giving information about earthquake).

7.2.3 Responsible stakeholder to Reduce Earthquake Risk

Table 40. Responsible Stakeholder to reduce earthquake risk

Responsible agency	No. of people	%
Community	35	42.17
Local agencies	28	33.73
Private\individual	20	24.10
Total	83	100

Source, Field Survey, 2015

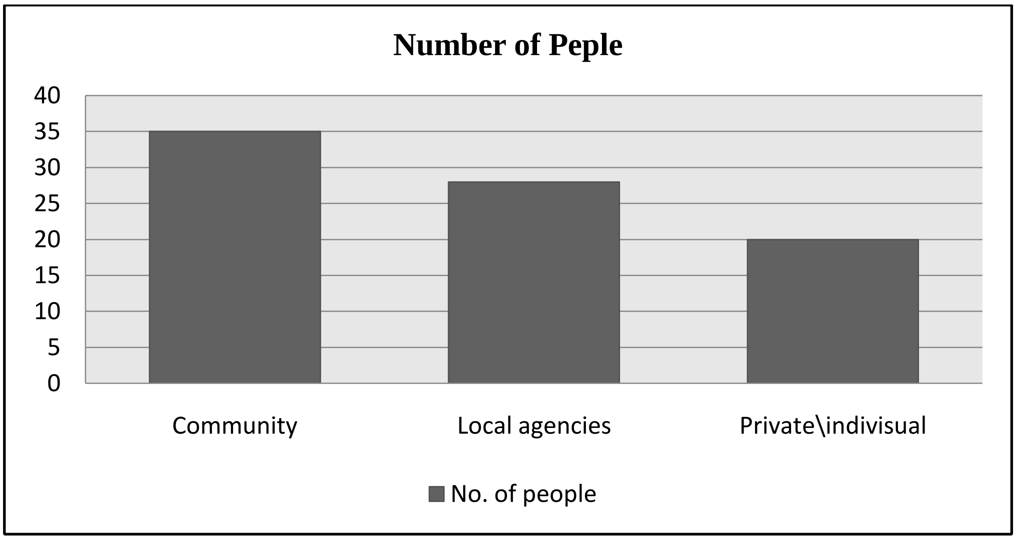


Figure 39. Responsible Stakeholders to reduce earthquake risk

In the field survey, when interacted with local people to know who is most responsible part to reduce earthquake risk in society, when earthquake occurred, it was found that 42 percent people respondent that community are more responsible to reduce disaster risk, 33 percent said that local agencies are responsible and only 24 percent people said that private or individual is responsible to reduce disaster risk.

7.2.4 Level of preparedness after earthquake event

In the study area it found that most people were found aware about emergency needs so 70 people save the money for their feature use in time of emergency. Most people were ignoring about life insurance although they know about it and its importance so it was found that only 26 people had done life insurance and 56 people had not.

Table 41. level of preparedness

Level of Preparedness	No. respondent of with positive answer (Yes)	No. respondent with negative answer (No)
life insurance	26	57
saving money	70	13
emergency kit	5	78
identity safe place	17	66
Early warning system	5	78

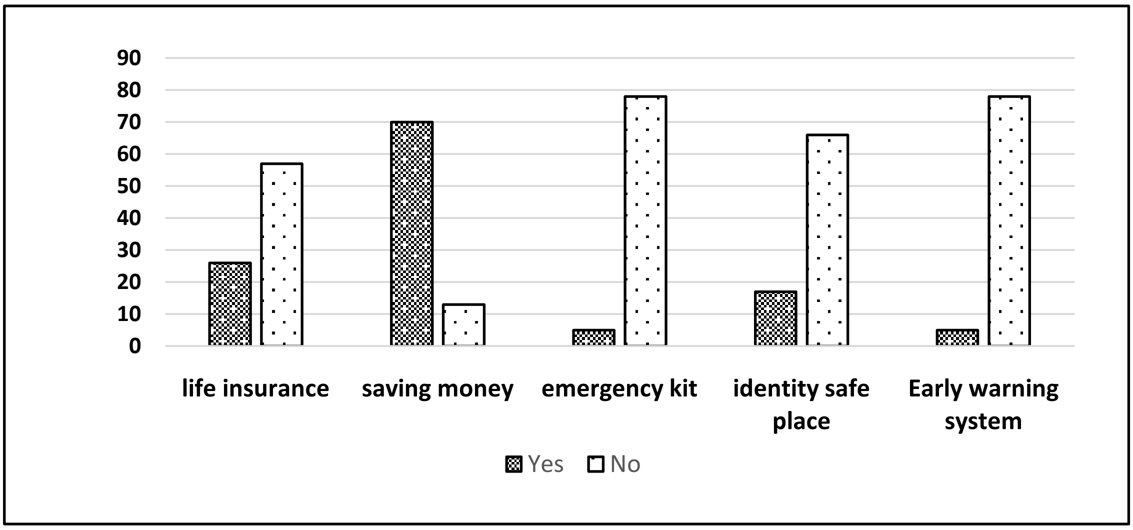


Figure 40 Level of preparedness

Likewise, regarding emergency kid few people know about it. Most of local inhabitants were not sure about occurrence about earthquake so they didn’t manage emergency kit among them 11 people know about it but only 5 people continued to manage it.

CHAPTER VIII

CONCLUSION AND RECOMMENDATION

8.1 Summary

The thought of aboriginal people, human beings was not cause of occurred earthquake but its real fact was gods are carrying this world on their shoulder, while Gods put the world in next shoulder because of tiredness, at that time when earthquake occur. During the earthquake, aboriginal people should come out in field or Yard (Keba) and another last option was stay between walls or pillars or door inside house for protection. The way of response of earthquake were shout saying “ha-ha-ha”, take name of Narayan, and press land by their thumb and also used “Jhyali and Huge Bells” for pre-information of disaster.

In the earthquake, 1990 about 100 or 300 people died, 30-40 houses were destroyed and 40-50 people were injured. Approximately 100 domestic animals died (including sheeps, goats, cows, buffalos, hens etc) and 2 main cultural heritages Chua Lachhi and Qua Lachhi were destroyed. Government had not given any support for healthcare, maintaining destroyed cultural heritage and peoples house .Those people who had no sons or only one son or not, they were given economic support for making house by Dwarika. People stayed in their fields by making tent (Balchha) for 2-3 weeks, making ten straw, straw mat (suku), bamboo etc were used.

Two nearest possible earthquake faults and scenarios to Thecho VDC are North Nuwakot Earthquake Scenario (MCT/7.6 mg), North-West Khokana Earthquake Scenario (LH/6.5mg). In case of North-West Khokana earthquake scenario 14 death at day and 32 deaths at night and 269 injuries at day time and 568 injuries at night time was estimate to be causality in the VDC. Similarly, 1280 houses were estimated to be damaged.

Among 5591 people in the Nuwakot Earthquake scenario, causalities are estimated that 51 people might found dead and 659 people were injured and for the total population 10086, causalities in the North Earthquake scenario is estimated that 116 people were found dead and 1414 people were found injured.

Out of the total population 5591, causalities in the North-West Khokana Earthquake scenario is estimated that 269 people were found injured and 14 people were found death in day time and at night time, the total population is 10086, where 568 people were found injured and 32 people were death.

Table 42. Seismic Faultline for Thecho VDC, Lalitpur

Seiemic Faultline for Thecho VDC, Lalitpur		
Total Population	10086	
No. of Buildings	1635	
Earthquake Scenario	Fault Name: MCT-3.3/Ms7.6	Fault Name: LH-4.9/Ms6.5
	Distance(Km): 37	Distance(Km): 2.55
	Direction: North	Direction: North West
Building Damage	1280 (78.3 %)	955 (58.4 %)
No. of Death (Day time)	51	14
No. of Injury (Day time)	659	269
No. of Death (Night time)	116	32
No. of Injury (Night time)	1414	568

The study found that, Out of the 1635 buildings (Thecho, 2015) in the VDC, 1280 (78.3 percent) buildings were found likely to be damaged, if the North Earthquake hits the VDC. Out of the 1635 building (Thecho, 2015) and (CBS profile) in the VDC, 955 (58.4 percent) building have been found damage, in the North-West Earthquake Scenario.

Damages on lifelines in the North Earthquake Scenario is estimated that damage percent of the local roads, major road, electrical and telecommunication transmission, Telecommunication sub-stations and major water and sewage trunk are 3.6, 2.1, 2, 15.2 and 1.3 percent respectively and damage percent of lifelines, local roads, major roads, major electrical and Telecommunication transmission sub-stations in North-West Earthquake scenario are same i.e 0.1 percent.

From the overall damage and casualties estimated by RADIUS, ward no. 9 possess the high vulnerability of building and in term of casualties because it has highest number of population.

Only 19.28 percent were aware of earthquake disaster. The knowledge and awareness of earthquake in Thecho VDC is based on questionnaires form sheet and 24 key informant people. Among total 107 respondents, 75 percent people were participated at earthquake awareness program which was held by DRM. But the other hand 25 percent people were not participated at earthquake awareness program but only get knowledge from the medial. People had not applied Jhatpt Jhola and Drop Cover and Hold in daily life but 80. 72 % people know about it. People had tradition method or strategies to be safe from earthquake occurred likewise 51.81 % people would go to open place, 24.10 % people were shouting, 19.28 % people would run away from the home. Local people had preparedness plane for emergence event. 70 % people had saved the money. 26 people had done life insurance and 5 % people had used emergency kit.

8.2 Conclusion

Indigenous people used shout saying “ha-ha-ha”, take name of Narayan, and press land by their thumb which were one indigenous way of response about occurred earthquake. “Jhyali and Huge Bells” were used for pre-information of disaster. In the earthquake, 1990 about 100 or 300 people died, 30-40 houses were destroyed and 40-50 people were injured. Approximately 100 domestic animals died (including sheeps, goats, cows, buffalos, hens etc) and 2 main cultural heritages Chua Lachhi and Qua Lachhi were destroyed. Government had not given any help a support for healthcare, maintaining destroyed cultural heritage and peoples house .Those people who had no sons or only one son or not, they were given economic support for making house by dwarika. People stayed in their fields by making tent.

More casualties were observed during night time because during night time most of the people are assumed to be inside their houses. May be rescue team have difficult to provide there service. North Earthquake scenario has been found more vulnerable than North-West Earthquake Scenario. It has shown that Thecho VDC is high risk of earthquake due to the poor construction of private building and lifeline. The vulnerability of building is dependent on the earthquake magnitude, distance from fault line, depth, direction etc. Likewise causalities depend upon mainly building damages and awareness and preparedness plan of people.

Spatial location of building damaged caused by 25th April 2015 is coincide with hypothetically earthquake scenarios. It seems that RADIUS method and tool is reliable and valid for the building damage estimation caused by the earthquake. Anticipated result is valuable for preparing preparedness and emergency plan to reduce to risk of potential damages and losses.

Very few people(19. 28 %) were aware of earthquake disaster. Most of people had not use Jhatpat Jhola and Drop Cover and Hold even included in awareness program. Maximum people, 75 percent people were participated at earthquake awareness program which was held by DRM. People had traditional method or strategies to be safe from earthquake occurred likewise 51.81 % people would go to open place, 24.10 % people were shouting, 19.28 % people would run away from the home. Local people had preparedness plane for emergence event. 70 % people had saved the money. 26 people had done life insurance and 5 % people had used emergency kit.

8.3 Recommendation

Compulsory to impose building code for newly construction building for minimize or reduce the earthquake vulnerability because earthquake hazard cannot be prevented.

People awareness and preparedness program should be launched in Village Development Committee, Disaster Risk Management Committee and Local community level by ward with concern institutions such as Clubs, Red Cross or VDC itself. Such program should include in the educational system. Community Disaster Preparedness Plan should be run and included in each plan prepared by VDC council.

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APPENDIX

Appendix 1. Demographic of Thecho VDC

Ward. No	**Male**	**Female**	**Household**	**5 % (HH)**
1	890	881	266	11.25
2	315	346	113	6.6
3	240	253	126	5.35
4	551	580	171	7.85
5	271	326	122	4.85
6	461	512	203	6.75
7	157	171	76	3.75
8	411	393	106	4.55
9	1638	1682	452	14.65
Total	**4942**	**5144**	**1635**	**65.6**

Appendix 2. Questionnaire

प्रश्नावलि सं.

Questionnaire

अदारनिय, यो प्रश्नावली नितान्त शैक्षिका अध्ययनको लागि मात्र प्रयोग गरिनेछ, । तपाईको यस सहयोगले मैले अध्ययन गरिरहेको भूगोल विषयको स्नात्तकोतर तहको सोधपत्र तयारीको लागि प्रयोग गरिने छ व्यक्तिगत विवरण र अन्य जानकारी गोप्य रखिने छन । धन्यवाद !

क. व्यक्तिगत विवरण

१. नाम.. २. लिङ्गः म....../पु....... उमेरः....................

३. ठेगानाः वडा नं. .... टोल...

४. तपाईको परिवरमाः

उमेर समुह	महिला	पुरुष	उमेर समुह	महिला	पुरुष
१० वर्ष मुनिको			४०-४९		
१०-१४			५०-५९		
१५-१९			६०-६९		
२०-२९			७० वष माथि		
३०-३९					

५. तपाईको शैक्षिक योग्यता कति छ होला ?

क. निरक्षर ख. साक्षर ग. प्राथमिक शिक्षा

घ. माध्यमिक शिक्षा ङ. उच्च माध्यमिक शिक्षा च. स्नातक वा सो भन्दा माथि

६. तपाई के काम गर्नु हुन्छ ?

क. मिस्त्री ख. ज्यामी ग. किसान घ. जागीरे ङ. विद्यार्थी

च. गृहिणी छ. बेरोजगार ज. उद्योग झ. व्यापार ञ. अन्य

ख) घरको बनावट

७. तपाईको घर कति पुरानो हो ....

८. तपाईको घर कुन प्रविधिबाट बनेको छ ?

क. आर. सी. सी पीलरवाला ख. ढुङ्गा/ईटाको गारोवाला भवन सिमेन्टको जोडाईमा

ग. ढुङ्गा/ईटाको गारोवाला भवन माटोको जोडाईमा घ. काठको Ply ङ. वाँस च. थोस वस्तु नभएको

छ. अन्य

९. छत /छाना के ले बनेको छ ?

क. आर.सी.सी ढलानको ख. जस्तापाता ग. टाईल घ. परालको छानो ङ. अन्य भए

१०. घरको गाह्रो /भिताको मोटाई कति छ ? क. ४" ख. ९" ग. १४ " घ. सो भन्दा माथि

११. चोकोस कसरी बनाउनु भएको छ । ....फलाम रड ठोकेर ....झ्याल ढोका चौको लामो ....छ .....छैन

१२. तपाईको घर कति तल्ले छ ?

१....... २...... ३....... ४...... ५....... ६.......

१३. तपाईंको घर वरिपरी खुल्ला ठाँउ ....छ ....छैन । ....वर्ग मिटर

१४. भान्सामा चुलोका रुपमा के प्रयोग गर्नु हुन्छ ?

क. डाउरा, छवाली, पराल ख. ग्यास ग. मटितेल

१५. चुलो सल्काएर आगो कसरी निभाउन हुन्छ ?...

१६. घरको क्षेत्रफल अन्दाजी कति छ ?

.....................वर्ग फिट वा ....वर्ग मिटर

१७. तपाईको घर अरुको घरसंग जोडिएको छ कि छैन ?

क. छ................ ख. छैन..........................

ग) प्रकोप बारे जानकारी

१८. तपाईले आफ्नो जीवनमा भुकम्प प्रकोप कसरी सामना गर्नु परेको छ ?

क. देखी ख. भोगी

१९. भुकम्पबाट हुन सक्ने क्षतिलाई घटाउनका लागि हालसम्म कुनै ठोस प्रयास भएको छ कि ?

क. छ....... ख. छैन....... ग. योजना हुदैछ........ घ. थाहा छैन.........

१८. छ भनेकोबाट के कस्तो प्रयास भईरहेको छ र त्यो प्रयास कुन चरणमा पुगेको छ कृपया छोटकरीमा उल्लेख गर्नुहास् ।

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१९. तपाई भूकम्प बारे कतिको सोच्नु हुन्छ ?

क. कहिले पनि सोच्दिन ख. धेरै सोच्दिन ग. कहिले काँही सोच्छु घ. अक्सर सोच्छु

२०. तपाईको क्षेत्रमा ठूलो भूकम्प आउला भन्ने कुरा तपाईलाई कतिको सम्भव लाग्छ ?

क. सम्भव छ ख. असंम्भव छ ग. धेरै संम्भव लाग्दैन घ. निश्चित लाग्छ

२१. भूकम्प आयो र त्यसबाट धेरै धनजनको क्षति भयो भने तपाई कसलाई दोष दिनु हुन्छ ?

क. भगवानलाई ख. सरकारलाई ग. गा.वि.स घ. डकर्मी

ङ. इन्जिनियरलाई च. आफैलाइ

२२. भूकम्प सम्बन्धी खतरा तथा बच्ने उपायबारे आफूलाई कत्तिको जानकारी छ जस्तो लाग्छ ?

क. केही जानकारी छ ख. केही पनि जानकारी छैन

ग. अरुलाई बुझाउन सक्ने जानकारी छ ङ. निजी घर र भूकम्प

२३. तपाईलाई घर भूकम्पबाट सुरक्षित बनाउने प्रविधि थाहा छ कि छैन ?

क. थाहा छ ख. थाहा छैन ग. निश्चित भन्न सकिँदैन

२४. तपाईको विचारमा घर बनाउँदा मुख्य ध्यान दिनु पर्ने विषय कुन हो

क. डिजाइन र सजावट राम्रो ख. किफायती ग. बलियो/सुरक्षित घ. सबै

२५. तपाईको घरलाई भूकम्पबाट पूर्ण सुरक्षित बनाउन के गर्नु पर्ला ?

क. पुरै भत्काएर नयाँ बनाउनु पर्छ　　　　　ख. केही मर्मत सुधार गर्नु पर्छ

ग. केही पनि गर्नु पर्दै　　　　　घ. थाहा छैन

२६. के तपाईको गाउँ टोलमा भूकम्पीय सुरक्षा उपाय अपनाएर घरहरु बनाइएको छन् ?

क. अहिले सम्म छैन　　ख. केही बन्न थालेका छन्　　ग. धेरै बनी सकेका छन्　　घ. थाहा छैन

घ) भुकम्प पछि प्रतिक्रिया

२७. विपद जोखिम घटाउनृ कार्यमा कस्को बढी भुमिका हुन्छ ?

क. समुदाय　　ख. निजी क्षेत्र　　ग. स्थानीय निकार्य

२८. भुचालो आयो भने के गर्नु हुन्छ ?

क. दौडिन्छु　　ख. टेबल मुनि लुक्छु　　ग. सुरक्षित (खुल्ला) स्थानमा जान्छु　　घ. कराउँछु

२९. घरमा कसैको जीवन विमा गर्नु भएको छ ?

क. छ　　ख. छैन

३०. बचत कहा गरि राख्नु भएको छ ?

क. बैंक　　ख. फ्याइनान्स्　　ग. सहकारी तथा समूह

३१. झटपट झोला र ड्गअप cover and hold बारे सुन्नु भएको छ ?

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३२. प्रकोपबाट जोगिने कुनै पारिवारिक योजना छ ? कस्तो ?

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३३. आपत विपतमा छिमेकी वा आफन्तले कसरी सहयोग गर्छन ?

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३४. विपत जोखिम न्यूनीकरण कार्यक्रमका लागि स्रोत साधन कत्तिको उपलब्ध हुने गरेका छन् ? कस्तो ?

....

....

३५. तपाईको समुदायमा सम्भावित जोखिम प्रति सचेत गर्ने वा पर्व सुचना दिने प्रणालीहरु छन ?

छन भने कस्तो ?

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३५. भुकम्प गएको कुन कुन साल याद छ ? कति घर भड्के, कति मठ मन्दिर भड्के, कति मानिस मारे, कति पल्तुपशु मारे ? छोटो विवरण दिनुहोस ।

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समाप्त

सहयोगको लागि धन्यवाद !

Appendix 3. Checklist for Key Informant Interview

१. ठेचो गा.वि.समा विगतको भुकम्पमा कति घर भत्क्यो ?

२. कस्ता घरहरु भत्केका थिए ?

३. पुर्णरुपमा क्षेति भएका घरहरु कति थिए ?

४. मानविय क्षति कस्तो भएको थियो ?

५. कुन कुन वडा कति घरहरु भत्केका थिए ?

६. स्थानीय रुपमा भुकम्प पिडितहरुलाई कसरी उद्दार गरियो ।

७. स्थानीय रुपमा भुकम्प पिडितहरु आफ्नो व्यवस्था कसरी र के क. गरे ।

६. भुकम्प पछि कस्ता राहतहरु वितरण भए ?

७. कुन कुन संस्था वा निकायबाट राहत वितरण भएको थियो ?

८. ठेचोको अवस्था अनुसार राहत वितरण कतिको उपयूक्त र प्रयाप्त थियो ?

९. स्थानीय सरकारबाट कस्तो सहयोग गरेको थियो ?

१०. गा.वि.सले पूर्ण र अशिंकरुपमा घर भत्केकाहरुलाई कसरी आर्थिक सहयोग गर्यो ?

११. सार्वजनिक सम्पित्ति (मठमन्दिर, विघालय) विग्रेकोमा गा.वि.सले कसरी सहयोग गर्यो ?

Check list for Stakeholder

१. अहिले भुकम्पको पुर्व तयारी कस्तो छ ?

२. ठेचो गाविसमा कुन कुन निकायले भुकम्पको पुर्व तयारीमा काम गरिरहेको छ ?

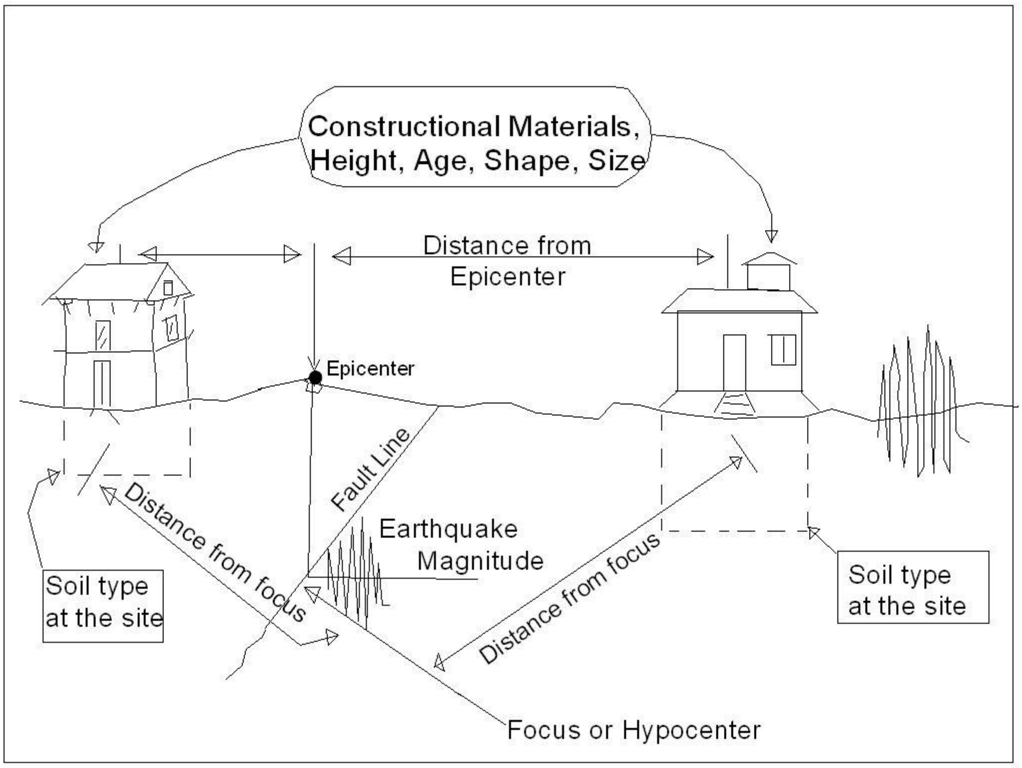
३. भुकम्प पछिको उद्दार टोली निर्माण भएको छ?

४. उद्दार टोलीको क्षेमता विकासमा कति को कार्य भइरहेको छ ?

५. अहिले यो निकायले गरिरहेको कार्यहरु के के हुन?

६. अवको भावि योजना केके छ ?

Appendix 4. Sketch Diagram about the BuildingVulnerability Factors



Source: Adopted from Guragain, 2004.

Appendix 6. Photographs

Figure 41. Questionnaire survey with local people

Figure 42. Religious and historical temple in Tallo Lachi

Figure 43. Different types of building

Figure 44. Damaged building after Earthquake 2015 (same picture location of fig. 43)