Chapter I
Introduction

1.1 Background

Nepal is a mountainous country. The mountains of Nepal were formed by the convergence of two continental plates, Tibetan plate in the north and Indian plate in the south. The Indian plate is moving at the rate of 1.5 to 5 cm per year depending on the location towards the north (Tianchi et al., 1996). It is formed due to this movement of plates. The ITS (Indus-Tsangpo Suture Zone) marks the northern boundary of the Indian plate, following the closure of the Tethys Ocean in the late cretaceous-early tertiary period (around 55-50 million years ago) (ICIMOD, 2000). The main cause of the earthquake in Nepal is the movement of the plate or plate tectonic. Nepal lies in the converging zone of two plates, due to the convergence of the plates the Hills and Mountains were formed, so the Hills and Mountains ranges of Nepal lies in the most active earthquake hazard zone.

Nepal is a disaster prone country and various disasters cause great loss of lives and property every year. Flood, landslide, droughts, wind storms, avalanches, debris flow, cloudburst, hailstorms, fire, earthquake and epidemics are recurrent disasters. Among the various kind or disaster earthquake is one of the most dreaded disasters. It is a natural phenomenon which depends upon various factors. Young and fragile geology, intense faulting and folding are the main causes of earthquake in Nepal. Unplanned settlement, lack of awareness and preparedness, poor construction of public buildings and houses especially in densely populated city or town etc. are the contributing factors that increase the vulnerability. Earthquake because of considerably destructive nature and it affects an overlarge concentration of material, property and population. In addition to the direct damage like collapse of building and other infrastructures left standing also become weakened for further use. According to UNDP/BCPR study (UNDP, 2004), among 200 countries, Nepal stands at 11^{th} position with regard to relative vulnerability to earthquake.

Nepal is known as one of the most seismic prone countries of the world. Large scale earthquakes have repeatedly hit the country. Earthquakes are natural phenomena which can not be avoided. Generally it creates a sense of panic and calamity in the minds of people, since many earthquakes have taken heavy loss of life and property in the past in this country. An average 32 persons are killed and Rs. 228.54 million's property is lost annually by earthquake in Nepal (Khanal et al., 2007). In 1839 earthquake happened in Kathmandu, Gorkha, and Makwanpur. In 1934, through out the country 24 persons were killed and 1300 houses were completely damage by the earthquake with the magnitude of 8.4 Richter scale. In 1966, earthquake happened in Darchula, Baitadi, Bajhang and Doti. Its magnitude was 5.2-6.3, by this earthquake 103 persons were killed, 391persons become injured, 25086 houses were completely damaged. In 1980, Bajhang, Bajura, Dadeldhura, Darchula, Baitadi, Doti, Achham, Humla, Mugu, Jumla, Kalikot, Dailekh, Jajarkot, Surkhet, Rukum and Salyan district were affected by earthquake with magnitude of 6.5-7. By that earthquake 721 persons were killed, 6993 persons were injured and 21976 houses were collapsed. In 1994, 84 houses were damaged in Jajarkot, 4 houses were damaged in Dailekh (Khanal, 1996). The earthquake of 1990B.S. is famous for large scale damage in Nepal. It was the most storable hazard, 8519 persons were killed. Nepali people have not forgotten that earthquake till now. According to the analysis of previous data it is believed that the large scale earthquake happens once in Nepal with interval of about 70-80 years so it is foreseeable that the next large scale earthquake might occur any time in the future. Earthquake of 7 Richter scale or grater is considered as large scale in Nepal (Shrestha, 2007). It shows that Nepal is most prone area of earthquake (see annex 7). Even now with the prevailing highly advanced state of knowledge, earthquake occurrence still remains a mystery and unpredictable and people are vulnerable.

1.2 Statement of the Problem

Earthquake is one of the most perilous natural hazards. It changes the morphology of the earth and settlements within minutes. Earthquake also induced other natural hazards such as landslide, GLOFS and other riverian floods. Although there were some studies have carried out on earthquake risk assessment in the different cities of Nepal like Kathmandu, Lalitpur, Bhaktput and other, Ilam municipality has not been studied yet, which was frequently victimized by earthquake. Nepal has faced the large scales of earthquake in lots of times as in 1890, 1990 and 2045 B.S. (www.nset.org.np 3 August 2008). No one can stop or control such types of natural hazards; however the loss could be minimized if proper preparedness and awareness actions are carried out. In order to develop effective preparedness plan it is necessary to know the degree of risk and vulnerability and responsible factors associated with human careless ness. In the context of population vulnerability, researcher arise some research questions which are as follows.

- What are the patterns of population distribution?
- How many peoples are vulnerable in different space and time period?
- What is the level of knowledge, awareness and preparedness?
- What is the level of injuries and casualties?

1.3 Objective of the Study

The general objective of the study is to determining the population vulnerability of Ilam Municipality. The specific objectives of this study are:

- To determine spatial and temporal distribution of population.
- To determine spatial and temporal vulnerability of population.
- To estimate probable injuries and casualties of population.

1.4 Significance of the Study

Nepal is a disaster prone country in which various disasters cause great loss of lives and property every year. Flood, land slide, fire, earthquake etc. are recurrent disasters. Nepal is a developing country the rate of construction of infrastructure is increasing mainly in urban areas. If we see the record of earthquake in Nepal since last 1255, in the difference of every 80 years a large scale (magnitude of grater then 8 rector scale) earthquake happen (www.nset.org.np 3 August 2008). In Nepal thousands of people and property have been losing in every year due to the earthquake. This study might be useful for the planners and concern origination to prepared better plan to reduce the vulnerability and risk form natural hazard as earthquake. The loss of life can be reduced if proper strategies are developed and implemented to cape with the risk of earthquake hazards.

This study will provide the basis for better planning and reduce the loss of life and property from earthquake.

1.5 Limitation of the Study

Due to the limited time and economic condition this study could not able to cover the whole aspect of human causality for earthquake hazard. It does not take account the human causalities due to secondary effects like heard attacks and other illness. This study also does not consider economic or financial losses and other social and property loss. This study is further confined to the estimation of probable human causalities based on the probability of only the building collapse and damage from earthquake event of intensity VII and VIII.

In this study the whole day categories into four time periods that are Morning (5 am-9 am), Day (9 am-5 pm), Evening (5 pm-9 pm) and Night (9 pm-5 am). Uses of buildings are categories in to 8 category that are residential, commercial, official, mix, hotel and lodge, hospital, school and campus building.

1.6 Selection of the Study Area

This study focuses on urban areas. Out of 58 municipalities, Ilam municipality is selected as a study area. In the case of vulnerability from earthquake urban areas are more vulnerable than rural areas because in the urban areas the population density is high and the buildings are compact so the

Ilam municipality is selected as a study area. This study might be represent the other hilly municipalities like Ilam. It is a historical hilly urban area located in the eastern development region of Nepal. It is developing without following any urban planning rules. The construction of building and other infrastructure in core area seems risky. The people, who are living in those buildings, are not aware as will as prepared about any kinds of natural hazards, which made this city more vulnerable during earthquake.

In the context of administrative situation, according to the CBS record, it was established in 1875 B.S. as headquarters of Ilam District and in 2015 B.S. it is declared as municipality. Ilam municipality has been divided in 9 wards .The population of Ilam municipality is 16246, among them 8337 are male and 7899 are female (Record of Ilam municipality 2058 B.S.). The population density is 5.7 persons/m^2. Chhetri, Brahmin, Newar, Tamang, Rai, Limboo, Kami, Damai etc. are the dominant caste ethnic groups in Ilam.

Different types of occupation have been adopted by the people in the Ilam municipality although agriculture is the main economic source. Ilam is a famous tourist area. It is also popular for tea garden. Ilam is one of the religious destinations of the country where there are various temples like Setidevi, Narayansthan, Maisthan, Gumpadanda etc.

Chapter II
Introduction to the Study Area

2.1 Study Area

Being a mountainous country, Nepal has been facing multi hazards problem from the ancient period. Among hazards earthquake is one of the noticeable hazard. Ilam municipality is also the hazards area for earthquake.

Map 2.1: Location of Study Area

Ilam municipality lies in Mechi Zone of eastern development region. Geographically it is situated between 26^0 54′ 00″ Northern latitude and 86^0 56′ 25″ East longitude. The area of municipality is 27.0 km^2, where urban area consist 2.71 km^2. The boundaries of Ilam municipality extend up to Maikhola in the east, Puwakhola in the west, Barbote VDC in the north and the southern boundary ends in the meeting point of Puwakhola and Maikhola. The elevation ranges from 401 meters to 1407 meters from the mean sea level. The study area is shown in the map 2.1.

2.2 Drainage Pattern

The main rivers are Maikhola in the east and Puwakhola in the west of the municipality. The drainage system of the municipality is shown in the map2.2

Map 2.2: Ilam Municipality: Drainage Pattern

Source: Topographical Survey Map, 2007

2.3 Landuse Pattern

The use of land is in diverse way. Mainly the landuse pattern of the study area has been classified as forest, cultivated land, tea garden, shrub and builtup area etc.

Map 2.3: Ilam Municipality: Landuse Pattern

Source: Topographical Survey Map, 2007

Table 2.1: Landuse Pattern of Ilam Municipality

Land use types	Area (km^2)	(%)
Built-up	0.7318	2.73
Bush	0.3169	1.18
Cultivation	16.0275	60.00
Forest	7.3848	27.62
Grass	0.7434	2.78
Plantation	0.4582	1.71
Sand	0.6823	2.55
Water body	0.3873	1.44
Total	26.7354	100.00

The table 2.1 shows out of total 60 percent land is cultivated 27.62 percent is forest and 1.18 percent is bush. Due to the growth of population forest area is transforming to the agricultural land. Settlement area highly concentrates in the middle part of the municipality which occupied 2.73 percent whereas cultivated land is extended in the western part of the municipality. The map 2.3 shows the landuse pattern of Ilam municipality.

2.4 Soil Types

Different types of soil are found in the study area. The main types of soil found in Ilam municipality are colluvial, moderately storn, residual, strong rock, and weak rock. Colluvial is the dominate soil type in the study area. Soils of the study area are classified according to their origin. Map 2.4 shows the soil types of the study area.

Map 2.4: Ilam Municipality: Soil Types

Source: Chamlagain et al., 2002

2.5 Geological Setting

Geology of the study area is dominated by the Precambrian to Cambrian Kyanite and sillimanite bearing genesis, biotype schist, metaquartizite, amphibolites, cal silicate genesis, orthogenesis and angiogenesis. The Mahabharata crystalline of the eastern Nepal are apparently continuous with the Darjeeling genesis of the Sikkim Himalayan (Chamlagain et.al., 2002).

Map 2.5: Ilam Municipality: Geological Setting

Source: Chamlagain et al., 2002

Unit 1= Garnet kyanite, sillimanite gnesis and gray quartzite
Unit 2= Garnet kyanite sillimanite gnesis, orthogenesis and
white colored, course grained fractured quartized

Available geological information indicates that great earthquakes with magnitudes in excess of 8 Richter scale have occurred on the area. In addition, extensive but more moderated seismicity has been associated with the same seduction zone.

Almost all of the areas pass directly through the fault areas. The fault is believed capable of producing earthquakes as large as magnitude 8 Richter scales. A large earthquake on the fault is of potentially catastrophic proportions. The map 2.5 shows the geological setting of Ilam municipality.

2.6 Population Distribution

The population distribution in the study area is not equal in all wards. The main concentration of population is in the core area of the municipality (ward no 1 and 2). In the periphery area the distribution of population are sparse. Map 2.6 shows the population distribution pattern of Ilam municipality.

Map 2.6: Ilam Municipality: Population Distribution

Table 2.2: Ward Wise Population Distribution

Ward No.	Male	Female	Total	%
1	502	462	964	5.94
2	1995	1789	3784	23.31
3	1062	971	2033	12.52
4	649	660	1309	8.06
5	780	769	1549	9.54
6	1104	1044	2148	13.23
7	627	620	1247	7.68
8	770	694	1464	9.02
9	848	890	1738	10.70
Total	8337	7899	16236	100.00

Source: CBS, 2001

The table 2.2 shows ward wise population of the Ilam municipality. According to the census 2001 the total population of the municipality is 16236. Among them 8337 are males and 7899 females. About 85 percent of population is Hindu, 12.8 percent Buddhist, and 2.0 percent are Kirat (MuAN, 2007). The ward wise population is shown in table 2.2.

2.7 Climatic Conditions

Ilam municipality lies in the hilly region of the eastern part of Nepal. Its altitude ranges from 401m to 1407m from mean sea level. The temperature ranges in between 50c minimum to 31.50 c maximum. The average temperature of this area is 210c and average rainfall is 2500 mm (official record of Ilam municipality).

2.8 Road Network

The map shows the road network of Ilam municipality. The road network of Ilam municipality consists of different categories like highway, major trail, minor trail other road etc. There are about 20 km length black-topped road, gravel road 12 km and earthen roads having 50 km in the municipality. There is still *Goreto* (trail) and, *Ghodeto* ways in the hilly area where people waked on foot.

Map 2.7: Ilam Municipality: Road Network

Chapter III
Research Methodology

3.1 Introduction

This part clarifies the methodological approaches applied, and contain a description on how data where collected and analyzed.

This study follows the methodology of HAZUS. HAZUS is loss estimation methodology integrated with GIS software program. It has been produced in the United State by the Federal Emergency Management Agency (FEMA) under a cooperative agreement with the National Institute of Building Science (HAZUS 1999). HAZUS is used for earthquake hazard mitigation emergency preparedness and response operations. It is US-nationally applicable earthquake loss estimation methodology (Guragain, 2004).

An empirical relation between collapse probability of buildings and population distribution, established by HAZUS, was used to estimate the casualties. Estimations were made for different severity levels for individual buildings due to different earthquake scenarios occurring in different periods of the day i.e. morning, day, evening and night. (Jimee, 2006).

This study was designed to estimate the probable injuries and casualties based on the distribution of population using other factors as external inputs. Here external input refers to the building vulnerability that is calculated using all the characteristics. Population vulnerability and casualties have been calculated on the basis of building vulnerability. So the basic steps that have been followed to calculate the population vulnerability, injuries and casualties are given in figure 3.1.

- Identifying the vulnerable buildings (derived from Khatiwoda 2008).
- Estimates of spatial and temporal distribution of population.
- Estimation of population vulnerability and probable casualties based on building vulnerability.

Figure 3.1: Research Sequence and Components

The research work has been divided into three Phase that are pre field work, field work and post field work.

3.2 Pre Field Work

The study started with the review of previous research about earthquake loss estimation and related fields. Ilam municipality was selected as the study area. On the basis of literature review the objectives were formulated.

As a base map an IKONOS panchromatic image with 1 meter resolution was used as the main base image to delineate the building units in the map, prepared by DUDBC. The whole study area was divided into 25 blocks that are smaller than the wards but bigger than individual buildings. The resulting map was printed in large scale overlaying the building footprint map on the IKONOS image. The buildings were categorized into 7 categories on the basis of using floors as residential, commercial, official, mix, hospital, hotel and lodge, school and campus. The whole day was categorized in to 4 time period as morning (5am-9am), day (9am-5pm), evening (5pm-9pm) and night (9pm-5am). After identifying the building type according to the uses of floors, stratified random sampling was adopted. Before the field visit, the sampled buildings were marked on the foot print first, and after visit the marked building the particular floor was chosen for the sample. Two type of questionnaire/survey forms were developed for the field data collection from which one for residential buildings and another for non-residential buildings. Both of them included questions about the respondents' knowledge, preparedness and attitude towards earthquakes. The questions related to family structures and household information was not included in the non-residential questionnaires.

3.3 Field Work

After preparing the foot prints of building and questionnaires, 40 days field survey was conducted from 28 October to 18 December 2007.

3.3.1 Sampling

Ilam Municipality of Ilam district was selected as the study area. After preparing the foot prints of the buildings, the floors were categorized according to their uses and stratified random sampling was applied. The total numbers of building were 3575, among these 27 buildings were used for schools and campuses. In the case of schools and campuses the floors are not taken as sample but the schools and campus were taken as sample. There were 25 schools and 2 campuses among those 22 schools and 1 campus were taken as sample. There were 6554 floors except school and campus. Among that 282 floors are taken as sample. Table 3.1 shows the sampled floors (see annex: 5 for sample buildings).

Table 3.1: Sample of Different Use of Floors

Uses of Floors	Total Floors		Sampled Floors	
	Numbers	%	No.	%
Residential	5921	90	245	87
Commercial	235	4	15	5
Office	241	4	12	4
Mix	101	2	8	3
Hotel and lodge	56	1	2	1
Total	6554	100	282	100

Source Field Survey 2007

Table 3.2: Sample of Schools and Campus

	Total numbers	Sampled	%
Schools	25	22	88
Campus	2	1	50

Source Field Survey 2007

During the field work each of the sampled building floors was visited and the adult persons present were interviewed. The respondent was not forced who didn't like to answer instead of that another alternative floors was visited. Table 3.1 shows 245 residential and 37 non-residential floors were interviewed. In the time of interview the population data were collected according to the population lived in the floor in different time. The question about the preparedness and awareness was also asked. The number of population did not match with the Central Bureau of Statistics (CBS) data because CBS has not taken the data according to different time period of whole day time as the people live in floor they have just collected the data of population of household. CBS has not included the population who are living in rent. But in that study the people who are living in rent has been included.

As for as school is concerned, a group discussion was held between teachers and researcher. They were asked question about the awareness, preparedness, and knowledge of earthquake. A full period was spent with the students and questions were asked to know the knowledge, awareness and preparedness of students about earthquake. Students have been observed through the class observation. In the case of campus class were not observed but teachers were interviewed, and number of students taken from the administration.

3.4 Post Fieldwork

After collecting the necessary data, the collected data was entered in the Micro Soft Excel program in computer. In order to calculate the population vulnerability to earthquake there is need to estimate the total population living in individual buildings in a particular time and as their uses. The population of the study area was calculated for different time periods and specific space uses by the population density factors which, was calculated from the sampled household survey. To find out population density factor, at first the sampled buildings' foot print area was calculated by using the ArcView GIS tools and it multiplied with their total numbers of floor (height). After estimating the total areas of each sampled building' the total area was calculated (summarized). Then the sampled population of different categories and different time (according to they live in the building) has been summarized. After getting the total area and total population by different uses of buildings and time the obtained population was divided by the total area. (For example the total foot print area of sampled residential building is 16801.907 and population of residential building in morning time is 1158 so, 1158/16801.907=0.07 here the 0.07 is the density factor of residential building in morning time) When, the density factors were found out, and the number of floors was multiplied by the foot print area to obtained the total building area (as the foot print area is 34.55 and the floor of particular building is 3, in that condition $34.55 \times 3 = 103.65$). To obtain the total population of the particular building, the total area of the building was multiplied by the density factor and gets the total population of the building (for example the total area of the particular building is 103.65 and the density factor is 0.07 in that condition $103.65 \times 0.07 = 7$, it means in that building there are 7 persons in particular time). Like that the whole building's population of different use and time's has been found out, and the whole population was projected as their buildings uses in different time period.

The type of building construction is a major factor controlling the number and severity of injuries due to earthquakes. The chances of collapse are high of masonry building, cracks building, old building, and non pillar break with mud building. The people who are living in such types of building are more vulnerable. However there are many factors that may increase the vulnerability or causality due to earthquake i.e. individual attitude, preparedness, awareness, age and socio cultural beliefs.

The following table 3.3 provides a straight casualty rates that have been used by Islam, which were basically developed by HAZUS-MH (2003).

Table 3.3: Injuries Severity Levels

Building Damage Level	Injury Level (in %)			
	Severity 1	Severity 2	Severity 3	Severity 4
Partial Damage	1	0.1	0.001	0.001
Completely Damage	40	20	5	10

Source: Islam, 2004

Table 3.4: Injuries Severity Levels Description

Severity Level	Injury Description
Severity 1	Injuries requiring basic medical aid that could be administrated by paraprofessionals. These types of injuries would require bandages or observation. Some examples are a sprain a severe cut requiring stitches, a minor burn (first degree or second degree on a small part of the body), or a bump on the head without loss of consciousness. Injuries of lesser severity that could be self treated are not estimated by HAZUS.
Severity 2	Injuries requiring a grater degree of medical care and use of medical technology such as x-rays or surgery but not expected to progress to a life threatening status. Some examples are third degree burns or second degree burns over large parts of the body, a bump on the head that causes loss of consciousness, fractured bone dehydration or exposure.
Severity 3	Injuries that pose an immediate life threatening condition if not treated adequately and expeditiously. Some examples are uncontrolled bleeding, punctured organ, other internal injuries, spinal column injuries or crush syndrome.
Severity 4	Instantaneously killed or mortally injured.

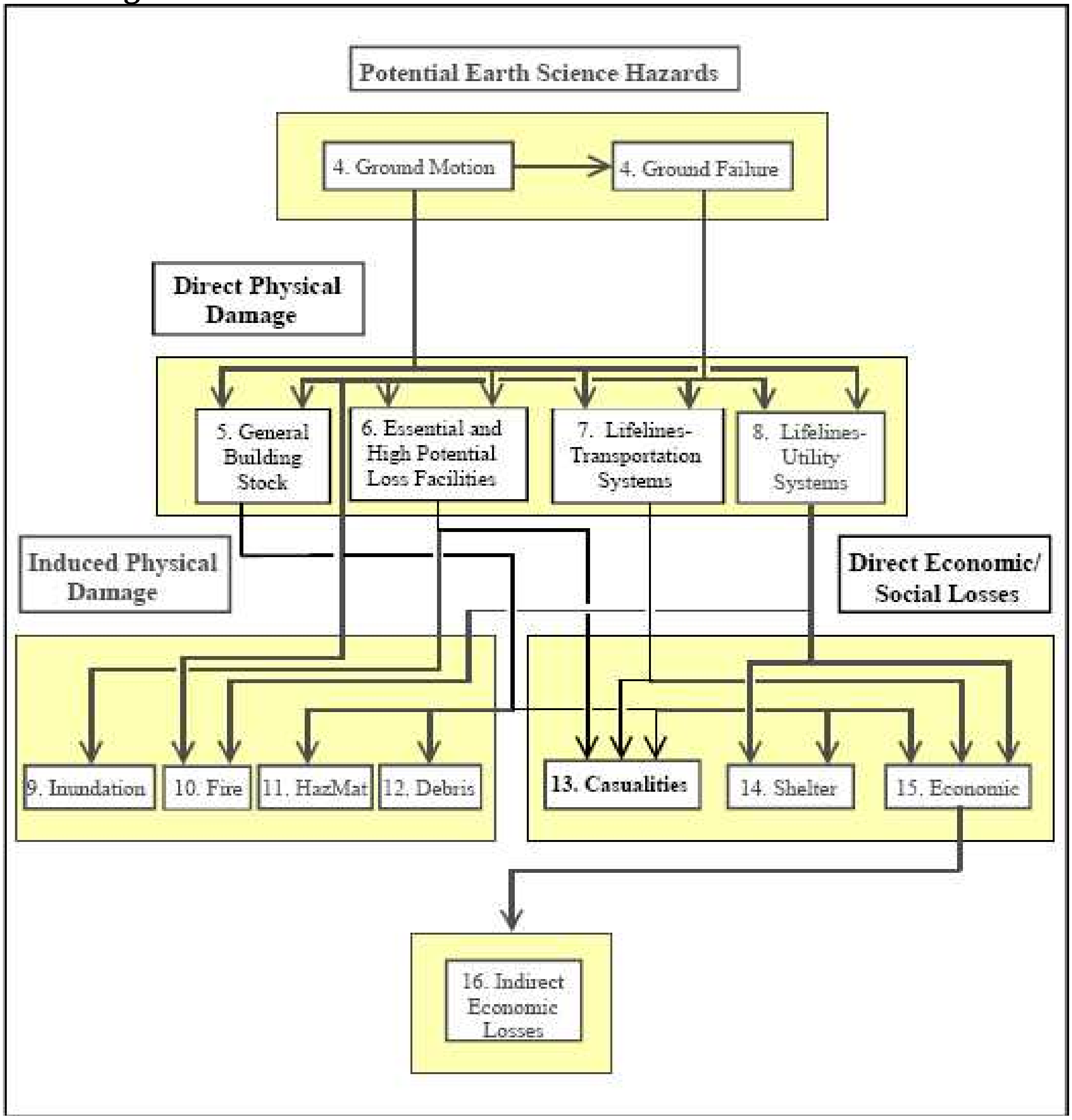
Source: Islam 2004.

The data of temporal and spatial distribution of population were collected from the field survey, and the data used for casualty estimation. For each cases (building damage and collapse), causality has been estimation for four different severity levels and four different time period (morning, day, evening and night). The casualties depend on the damage and collapse probability of building in different earthquake intensity and number of person present in that building following the injury ratio given in table 3.4.

3.5 Use of HAZUS Methods

United States Federal Emergency Management Agency developed HAZUS methods. It is based on a multi-year project to develop a nationally applicable methodology for estimating potential earthquake losses on a regional basis. The project has been conducted for the National Institute of Building Science (NIBS) under a cooperative agreement with the Federal Emergency Management Agency (FEMA).

Figure 3.2: The Overall Framework of the HAZUS Method



The primary purpose of the project is to develop guidelines and procedures for making earthquake loss estimates at a regional scale. These loss estimates would be used primarily by local, state and regional officials to plan and stimulate efforts to reduce risks from earthquakes and to prepare for emergency response and recovery. A secondary purpose of the project is to provide a basis for assessing nationwide risk of earthquake losses.

The scope of this module is to provide a simple and consistent frame work for earthquake casualty estimation and formats for data collection and data sharing across the disciplines that are involved in casualty estimation. Many recognized relevant issues in casualty estimation such as occupancy potential, collapse and non-collapse vulnerability of the building stock, time of the earthquake occurrence, and spatial distribution of the damage, are included in the methodology.

Chapter IV
Literature Review

4.1 Concept of Earthquake Hazard

To complete this research different related terms and literature has been reviewed.

Earthquake: Earthquake is a sudden and violent movement, or fracture, within the earth followed by the series of shocks resulting from this fracture. The point of origin of an earthquake is known as the epicenter (A Dictionary of Geography, Oxford). The scale of the shock of an earthquake is measured by seismograph. Mainly earthquakes are two types, vertical and horizontal. Horizontal earthquake be more dangerous than vertical earthquake.

A sudden mutation or vibration in the earth caused by the abrupt release of energy in the earth's lithosphere. The wave motion may range from violent at some locations to imperceptible at others (FEMA, 1990). An earthquake is a sudden shift or movements of the earth's crust caused by the release of stress accumulated along geologic faults or volcanic activity (Pandey, 1999)

Vulnerability and Risk: The terms vulnerability and risk have specific meaning. "Vulnerability means the degree of loss to a given element or a set of elements at risk resulting from the occurrence of a natural phenomenon of given magnitude" (ICIMOD 2001, quoted Islam 2004). Risk can be defined as expected degree of loss due to particular natural phenomena. So risk can be expressed as a function of vulnerability. It is possible to estimate the risk for any natural hazard to some extent if certain parameters are known. The scale and degree of severity is different for various types of hazards and at the same time the types of elements at risk are also different.

Vulnerability is the degree of losses to a given magnitude. It can be viewed from physical, spatial (location) and socio-economic characteristics of a region (Khanal, 1996)

Earthquake Magnitude: Magnitude is the measuring scale of the shock of an earthquake. Earthquake magnitude is an expression of the total energy released. It's related to ground acceleration of the area from where the energy is released. The most commonly used scale is the 'Richter scale' The intensity of an earthquake can be measured by the Mercalli scale.

Mercalli Scale: Mercalli scale is a measurement of the intensity of an earthquake. The table 4.1 shows the Modified Mercalli Scale of Earthquake Intensity.

Table 4.1: MMI Scale

MMI	Descriptions of characteristic effects
I	Felt by very few, except under special circumstances.
II	Felt by a few persons at rest, especially on the upper floors of buildings.
III	Felt noticeably indoors, although not always recognized as an earthquake. Vibration like passing lorry.
IV	Felt by many indoors during daytime, but by few outdoors. Some awakened at night. Vibration like lorry striking building.
V	Felt by nearly everyone; many awakened. Some breakages, disturbances of trees, telephone poles.
VI	Felt by all; many run outside. Some heavy furniture moved.
VII	Everyone runs outside. No damage in well-built buildings; moderate damage in ordinary structures; considerable damage in poorly constructed buildings.
VIII	Considerable damage except in specially constructed buildings. Disturbs people driving cars.
IX	Damage even specially designed structures. Buildings shifted from foundations; ground cracked; underground pipe broken.
X	Ground badly cracked. Rail way lines bent. Landslides considerable.
XI	Few brick-built structures remain standing, if any. Bridge destroyed. Broad fissures in the ground.
XII	Total damage. Waves observed on ground surface. Objects thrown upward into the air.

Source: A Dictionary of Geography Third Edition

Damage and Collapse: Building damage refers to the probability of being partially damaged of a particular building (reparable) and collapse refers to the probability of being complete damaged (non-reparable).

Hazard: Hazard is an event that is something dangerous and harmful. (Burton et al., 1978 cited in Islam 2004) defined hazard as "……elements of the physical environment, harmful to man and caused by forces extraneous to him". Hazard refers to 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).

4.2 Previous Studies

In Nepal some studies about earthquake hazard has been carried out in the urban area among those some available previous studies has been reviewed that are:

Islam (2004), in his report "Population Vulnerability Assessment for Earthquake in Lalitpur Nepal" he concluded that casualty levels are more influenced by building collapse then partially damaged. In the case of temporal total casualty in case of earthquake happening at night is slightly higher than earthquake happening at day time. As more people stay in residential building during night time, he also concludes that residential buildings are comparatively more vulnerable.

He has used the HAZUS methodology in his study. He calculates the population vulnerability on the basis of distribution of population and the building vulnerability. The whole studies have mainly three components, identifying the homogeneous units, estimating the spatial and temporal distribution of population and estimating the number of casualties.

Jimee (2006), in the title "Seismic Vulnerability and Capacity Assessment at Ward Level a Case Study of Ward No. 20, Lalitur Sub-metropolitan City, Nepal" he has concluded that 1602 and 401 casualties respectively for severity 1 (minor injury) and 4 dead in ward no 20 due to an intensity IX earthquake occurring at day time, and 1607 and 402 for the night time proportionality more casualties were estimated in nonresidential at night. Moreover, proportionality very high casualty rates were estimated in school class rooms during day time and school hostel during night.

He collected the information through the house hold survey for a sample 5% of the total 3329 building floors. Population density was calculated for the sampled building floors according to space uses for different time period of the day. Building damage and collapse probability were estimated for individual building considering their condition in addition to building height, construction types and earthquake intensity using an existing damage matrix prepared by JICA and NSET Nepal.

Guragain (2004), in his research entitled "GIS for Seismic Building Loss Estimation: A case study form Lalitpur Sub-metropolitan City Area, Kathmandu Nepal". He used the building damage matrix developed by JICA and NSET Nepal in his studies.

The seismic building damage matrix for earthquake intensities ranging from VI to IX for the various building type in Kathmandu valley, which was prepared by NSET Nepal was used in his study. GIS operations were preformed to link this relation to the building types in the Lalitput area in order to find out the number of damaged building in different damage states.

In his study he concluded, according to the earthquake type and expected intensities, buildings with probability of partially damage were estimated ranging from 1013 (4%) to 13710 (51%) similarly collapse building were estimated ranging from 641 (2%) to 8583 (32%).

Tung (2004), in the topic "Road Vulnerability Assessment in Earthquake a Case Study of Lalitpur, Kathmandu Nepal". He concludes that the distance between the building and the road influence the possibility of the road blockage. The longer distance the lower possibility of road blocks. The building characteristics also effect as cantilever, construction materials, height of the buildings etc. The building cantilever is more likely to collapse than other buildings without cantilevers. Evaluation of the road blockage possibility related to the construction material and types of the main structure of buildings. Masonry building (Brick cement, brick mud, and adobe) is likely to disintegrate and collapse vertically so the debris is likely not to go far away from the building plan. Mean while 'Rigid' buildings (reinforce, concrete, steel) are likely to less collapse towards on side. The rigid building even though they seem to be stronger than soft masonry buildings are likely to lean forward to the collapsing side. Once they collapse, causing debris to go far away from the original building position. Higher the building height along the road side higher the chance of road blockage at the time of earthquake.

Chapter V
Spatial Distribution

5.1 Spatial Distribution of Population by Use Types of Floor

The sampled population has shown into spatial distribution of population which represents the floor wise population.

The spatial distribution pattern of the population has been calculated from the sample survey data. The survey was conducted on different uses type of building residential, commercial, official, mix, hotel and lodge. The population data of Schools, campus and hospital's has not been included here. According to the sample survey the spatial distribution of population has been shown in the table 5.1.

Table 5.1: Floorwise Population Distribution

Floor No.	Male	%	Female	%	Total	%
1	330	46.28	277	39.18	607	42.75
2	357	50.07	399	56.44	756	53.24
3	21	2.95	16	2.26	37	2.61
4	5	0.70	15	2.12	20	1.41
Average	178	25	177	25	355	25

Source: Field survey, 2007

Figure 5.1: Floorwise Population Distribution

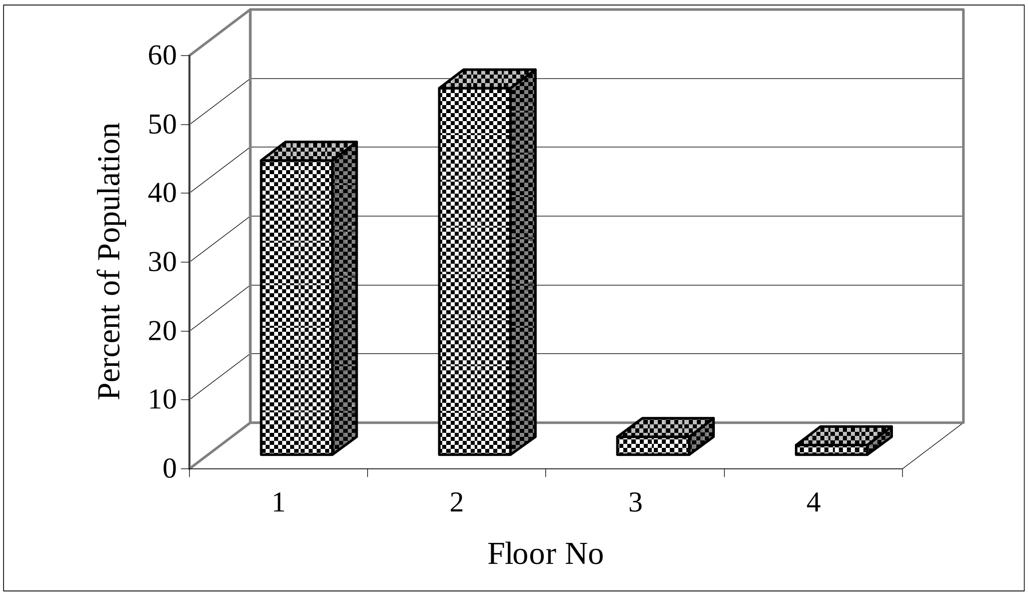


Table 5.1 and figure 5.1 shows the floorwise (spatial) population distribution of the study area. Out of total 1420 people, 53.24 percent live in

second floor, 42.75 percent in first floor and only 1.41 percent live in fourth floor. In the residential building most people are live or sleep in second floor. The old people above 80 years are also live in second floor although they feel difficult to climb up and down the ladder. In the study area mostly first floors are used as kitchen and top floor as store of foods and other. In the case of commercial building mostly the first floor are used for commercial activities. No distinction can be found in the use of other buildings.

5.1.1 Residential Use of Floors

Table 5.2 shows out of 1096 sampled people more then 60 percent used the second floor as residential, among them 26 persons are above 70 years. These data shows that very old people are using the second floor as residential. 34.41 percent people are using the first floor as residential among them 15 persons are above 70 years. Some people are using third and fourth floor for residential use. 3 above 70 years persons are using the third floor as residential (field survey 2007). In the residential building mostly the people who have more then two storeys building they use the first floor for kitchen and second for residential (sleep) and third or more for store of food.

Table 5.2: Population Distribution by Use of Residential Floors

Floor No.	Male	%	Female	%	Total	%
1	182	35.17	195	33.72	377	34.41
2	312	60.42	352	60.75	664	60.59
3	18	3.44	16	2.81	34	3.11
4	5	1.02	15	2.63	21	1.87
Average	129	25.00	145	25.00	274	25.00

Source: Field survey, 2007

5.1.2 Commercial Use of Floors

Table 5.3 shows the population distribution of commercial use that has been taken from sample survey. In commercial building mostly the first floors are used for commercial activities. Out of 260 people about 88 percent are engaged in commercial activities in first floor and only 1.54 percent are using the third floor for commercial activities. This table shows that people give first priority for first floor (ground floor) than second and other floors. This table also shows normally males and females are equally engaged in the commercial activities in each floors. Here the customer and sellers are considering as commercial people.

Table 5.3: Population Distribution by Use of Commercial Floors

Floor No.	Male	%	Female	%	Total	%
1	59	90.77	55	84.62	114	87.69
2	4	6.15	8	12.31	12	9.23
3	1	1.54	1	1.54	2	1.54
4	1	1.54	1	1.54	2	1.54
Average	16	25.00	16	25.00	33	25.00

Source: Field survey, 2007

5.1.3 Mixed Use of Floors

The table 5.4 shows out of total 45 people more then 57 percent are using the first floor for mixed use as commercial, residential as well as other uses. 34.29 and 8.57 percent people are using the second and third floor for mix use respectively. According to this table more people want to use the first floor for mix activities. Mostly the mix floors are used for the commercial use in day time and resident in night time. The front rooms are used for commercial and small hotel and back rooms are used for resident purpose.

Table 5.4: Population Distribution by Use of Mixed Floors

Floor No.	Male	%	Female	%	Total	%
1	11	55.00	9	60.00	20	57.14
2	6	30.00	6	40.00	12	34.29
3	3	15.00	0	0.00	3	8.57
4	0	0.00	0	0.00	0	0.00
Average	5	25.00	4	25.00	9	25.00

Source: Field survey, 2007

5.1.4 Official Use of Floors

Table 5.6 shows that out of total 404 people 95.54 percent are using the first floor for official activities. Only 4.46 percent people are using the second floor for official use. In the time of sample the government and non government office has been included. Floor three and four are not used for official use. This table also shows that the females are less participate in official activities in first floor 314 male are engaged in official works and only

72 women are engaged in official works. Except employers the person who come in different offices for official work, are more male then female.

Table 5.5: Population Distribution by Use of Official Floors

Floor No.	Male	%	Female	%	Total	%
1	314	97.82	72	86.75	386	95.54
2	7	2.18	11	13.25	18	4.46
3	0	0.00	0	0.00	0	0.00
4	0	0.00	0	0.00	0	0.00
Average	80.25	25.00	20.75	25.00	101	25.00

Source Field Survey 2007

5.1.5 Population Distribution According to Building Type

In the study area people are using different types of building for different use as residential, official, school, commercial etc. The probability of building damage or loss would not be equal. Many things control the chance of building loss as material use, building's height, width of wall, age, soft story etc. The adobe buildings have high probability of being collapse compared to other building types followed by brick in mud and brick in cement buildings (Jimee, 2006). According to the building use the vulnerability of population will be different. The table 5.6 shows the sample population distribution by types of buildings and time.

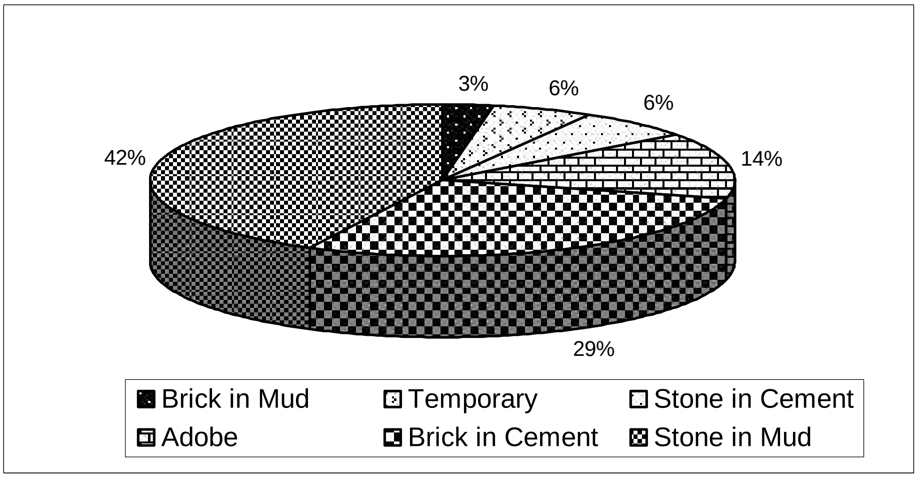
Table 5.6: Population Distribution by Type of Building and Time

Building type	Morning	Day	Evening	Night	Average	%
Adobe	213	123	232	228	199	14
Brick in Mud	41	29	45	45	40	2.82
Brick in Cement	437	465	414	309	406	28.61
Stone in Mud	632	378	694	714	605	42.57
Stone in Cement	91	83	100	94	92	6.48
Temporary	107	109	61	36	78	5.51

Source Field Survey 2007

Table 5.6 and figure 5.2 shows that most of the population use the stone and mud building for different use as residential, commercial, official, and so on. Out of average total 1420 people more then 42 percent of the sample people are using the stone in mud building; some people are using the brick in mud buildings. Only 2.82 percent people are using the brick in mud about. 29 percent people are using brick in cement building, 14 percent people are adobe, 6.48 percent people are stone in cement and 5.51 percent people are using the temporary building for different types of use.

Figure 5.2: Population Distribution by Type of Building and Time



The spatial distribution patterns of population were not in floor use. The second floor is highly used for residential purpose. Nearly 70 percent of residential people are used second floor. First floor is used highly for commercial, mix as well as official purpose. More than 88 percent, 57 percent and 95 percent people used the first floor for commercial, mix and official activities respectably. It means in the Ilam Municipalities second floor are used mostly for residential, hotel and lodges. First floors are used highly for other activities. In the case of building use mostly stone in mud buildings are used for different types of activities. About 43 percent of sample people are used the stone in mud buildings for residential purpose, commercial, mix, official and so on. Only 2.28 percent people are used the brick in cement buildings for different type of activities.

Chapter VI
Temporal Distribution of Population

To find out the temporal distribution total time of whole day has been divided in four types depending on the socio-economic characteristics at movement pattern of the study area. They are shown in the table 6.1.

Table 6.1: Time Distribution

Time	From	To
Morning	5 am	9 am
Day	9 am	5 pm
Evening	5 pm	9 pm
Night	9 pm	5 am

Day time starts at 5 am in the morning when the people starts for this workplace. With in 10 o’clock all the offices and other work placed start their daily activities so the people started to go office or other working place form 9 am and they remains there till 5 pm. After 5 pm they come back in home or residential place. After the 5 pm according to the Nepali culture at the evening time people prepared dinner and take it before 9 pm. normally after the 9 pm people started to sleep till 5 am. So the whole time of day has been divided on that concept.

The temporal distribution of population in the study area is not equal. Sample people of Ilam municipalities are engaged in different occupation and function. According to their occupation some people live inside the house and some people live outside the building. The people who are engaged in the agriculture they may not be inside the home at the day time and the people who are engaged in the job they may not be inside the official building at morning. Students and teachers are found in the school’s building at day time. So the table 5.8 shows the temporal distribution of people live inside the building of different time period. In the evening the maximum people found inside the building so the evening time has been taken as consentient in that time 1526 people live inside the floors, which is maximum number then other time period. In that table the students and teachers are not include. If students and teachers include by sample building of schools and campus, the distribution seen very high in day.

Table 6.2: Percent of Population Living Inside the Floors by Time

Time	Male	%	Female	%	Total	%
Morning	744	48.75	727	47.64	1471	96.40
Day	501	32.83	586	38.40	1087	71.23
Evening	807	52.88	719	47.12	1526	100.00
Night	731	47.90	695	45.54	1426	93.45
Average	696	45.59	682	44.68	1378	90.27

Source Field Survey 2007

Figure 6.1: Percent of Population Living Inside the Floors by Time

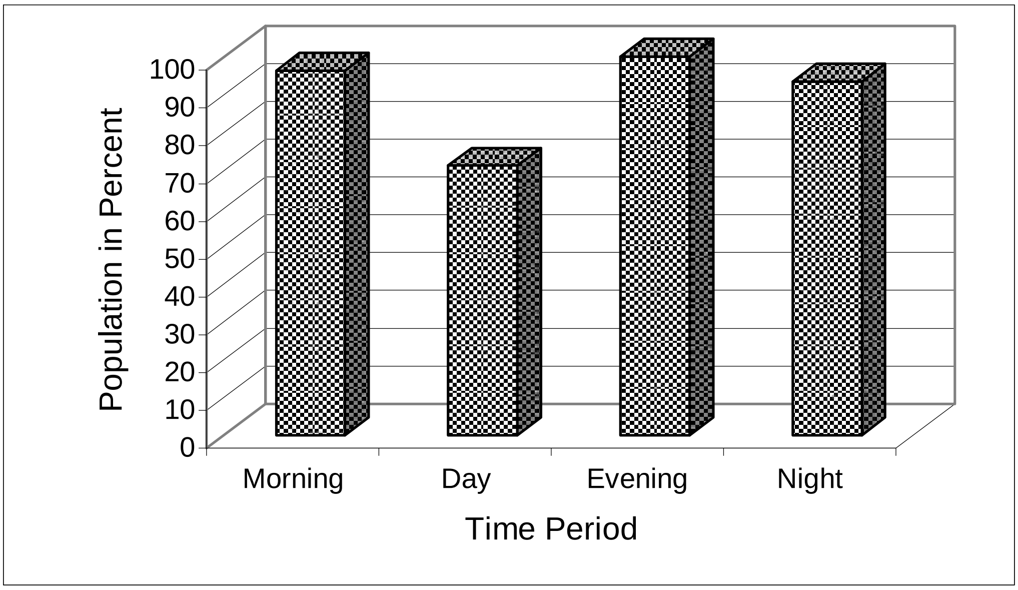


Table 6.2 and figure 6.1 show the temporal distribution of population. According to the table 6.2, maximum people lived inside the building of sample floors during evening time. More then 96 percent people are living in floors at morning. 93.45 and 71.23 percent people are found inside the building of sample floors at night and day time respectively. Average in the sample floors 90.27 percent people live during all time inside the buildings. This data seen little abnormal, normally people thinks that mostly people live in building at night but in that study the data has been taken from the different types of work field. In the case of commercial, official, mix, building more people is not live inside the floors during the night time so the people at evening seen more than other time period.

6.1.1 Morning Time

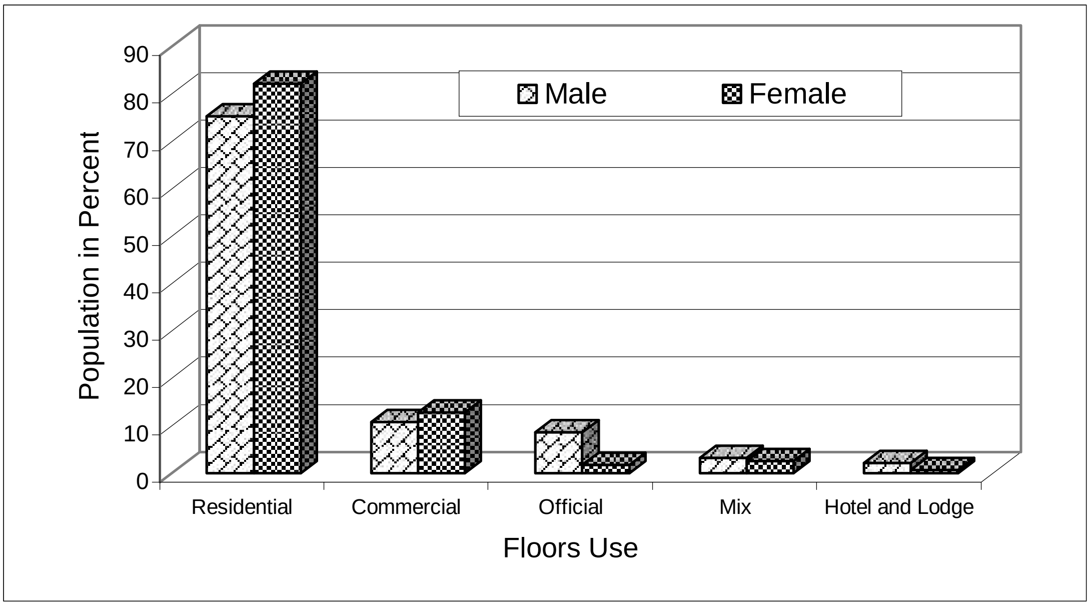
Table 6.3 and figure 6.2 shows the distribution of population during morning in the different floors use.

Table 6.3: Distribution of Population in Morning Time

Floors use	Male	%	Female	%	Total	%
Residential	560	75.27	598	82.26	1158	78.72
Commercial	80	10.75	93	12.79	173	11.76
Official	64	8.60	13	1.79	77	5.23
Mix	24	3.23	18	2.48	42	2.86
Hotel and Lodge	16	2.15	5	0.69	21	1.43
Total	744	100	727	100	1471	100

Source Field Survey 2007

Figure 6.2: Distribution of Population in Morning Time



In the study area out of 1471 population about 79 percent residential people dwell in side the residential floors. Only 2.43 percent people are found inside the Hotel and Lodge floor during the morning. In the morning time maximum people found inside the residential floors because they go out after 9 am in the different working place. The commercial activities start form early morning but the office start after 10am so in the official floors only 5.23 percent people are found during morning time. The persons who are found in the official floors during morning time, they are using the office as a working place during day and residential during night.

6.1.2 Day Time

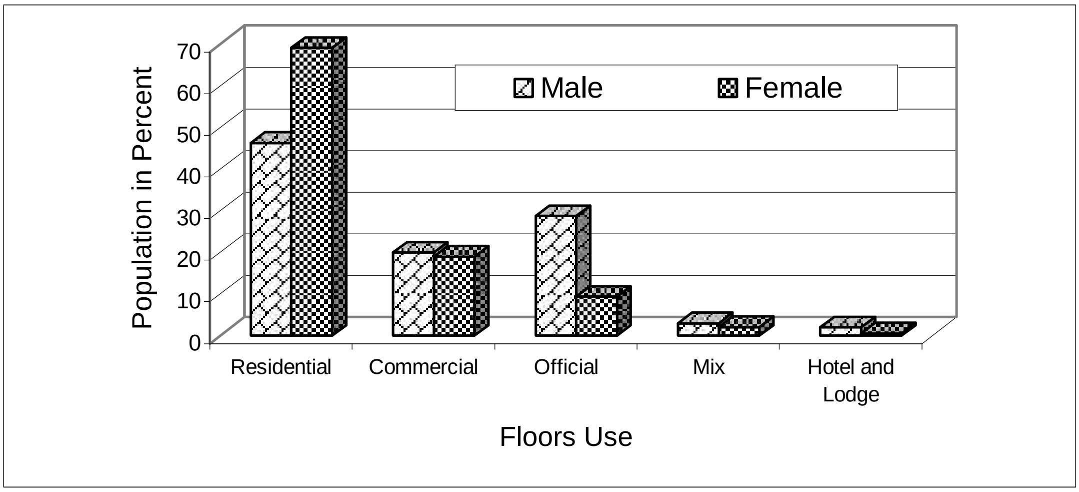
During the day time period people found more inside the commercial and official floors then morning. Table 6.4 and figure 6.3 show out of 1087 persons about 59 percent people found in the residential floor during day time. It is less than other time. Among them mostly female people are remains inside the building during day time. More then 19 and 18 percent people are found inside the commercial and official floors during day time, which is maximum than other time period. In the day time 69.11 percent female and only 46.31 percent males lived in the residential floors during day time. In the commercial floor the female are found maximum than male. In the official floors males are found nearly 3 time maximum than females. In the mix hotel and lodge floors 2.48 and 1.2 percent people are found during day time, which is less than other time period. Ilam is a tourist area so in the hotel and lodge mostly internal tourist goes to take entertainments and see the scene and scenarios during day time.

Table 6.4: Distribution of Population in Day Time

Floors use	Male	%	Female	%	Total	%
Residential	232	46.31	405	69.11	637	58.60
Commercial	100	19.96	111	18.94	211	19.41
Official	144	28.74	55	9.39	199	18.31
Mix	15	2.99	12	2.05	27	2.48
Hotel and Lodge	10	2.00	3	0.51	13	1.20
Total	501	100.00	586	100.00	1087	100.00

Source Field Survey 2007

Figure 6.3: Distribution of Population in Day Time



6.1.3 Evening Time

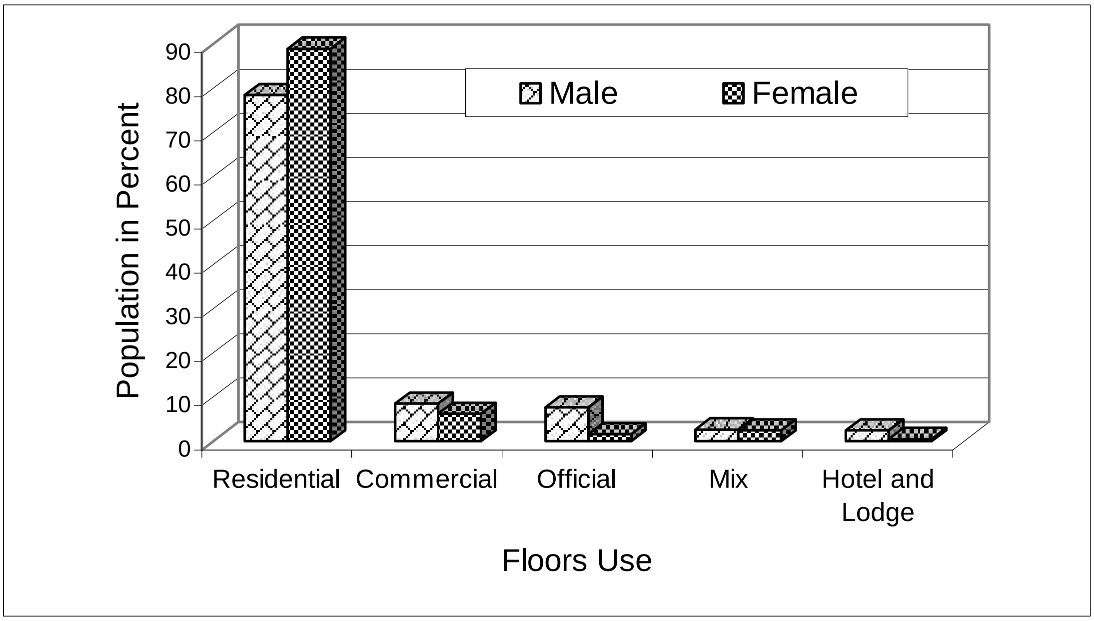
Table 6.5 and figure 6.4 shows the population distribution during evening time. In the evening out of 1526 people more then 83 percent people are found inside the residential floors. 7.47 percent people are found in the commercial floors, which is less presence than morning, day and more than night. Only 4.85 percent people are found in the official floors, which is nearly 4times less than during day time. In the mix, hotel and lodge floors 2.62 and 1.57 percent people are found respectively. In the evening time the residential people come back form their working place and the students also come back during evening from school and campus so the maximum people found in the residential floors. In the residential floors numbers of females are more then male and other floors the numbers of males are more then female.

Table 6.5: Distribution of Population in Evening Time

Floors use	Male	%	Female	%	Total	%
Residential	634	78.56	640	89.01	1274	83.49
Commercial	69	8.55	45	6.26	114	7.47
Official	62	7.68	12	1.67	74	4.85
Mix	22	2.73	18	2.50	40	2.62
Hotel and Lodge	20	2.48	4	0.56	24	1.57
Total	807	100.00	719	100.00	1526	100.00

Source Field Survey 2007

Figure 6.4: Distribution of Population in Evening Time



6.1.4 Night Time

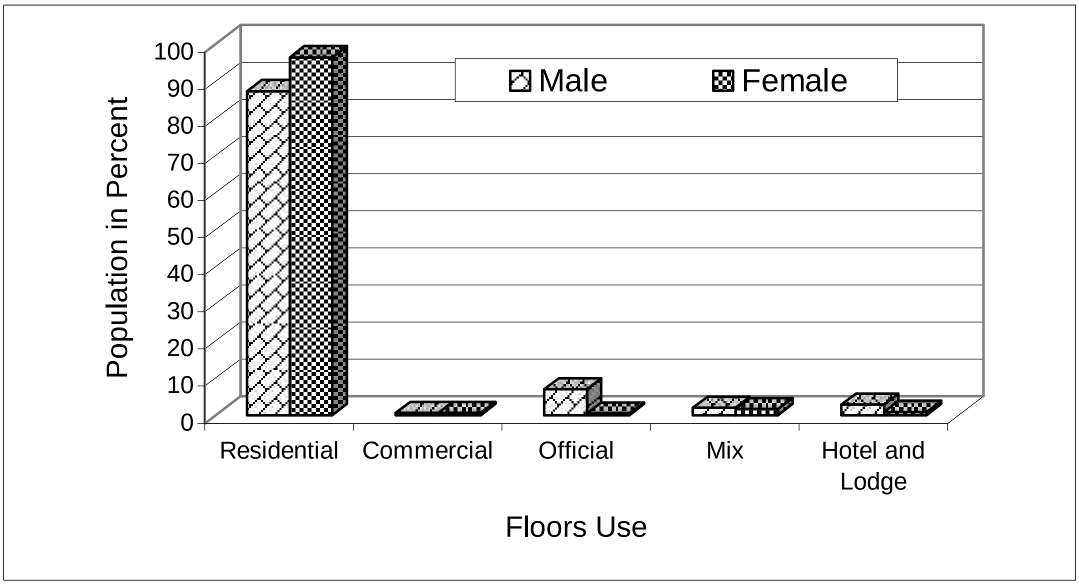
Table 6.6 and figure 6.5 shows the distribution of population in different uses of floors in night times. The highest numbers of people (91.87 percent) are in the residential floor in this time period followed by official floor with 3.79 percent. During the night all types of commercial activates stopped in the study are so the presence of persons found very minimum (0.63 percent). The survey figure shows that people does not like to remain outside during evening and night. All people want to remain with their family at evening and night.

Table 6.6: Distribution of Population in Night Time

Floors use	Male	%	Female	%	Total	%
Residential	639	87.41	671	96.55	1310	91.87
Commercial	5	0.68	4	0.58	9	0.63
Official	51	6.98	3	0.43	54	3.79
Mix	15	2.05	11	1.58	26	1.82
Hotel and Lodge	21	2.87	6	0.86	27	1.89
Total	731	100.00	695	100.00	1426	100.00

Source Field Survey 2007

Figure 6.5: Distribution of Population in Night Time



According to sex of people, the highest numbers of female (96.55 percent) are found in the residential floor and 87.41 percent of male are found in same time. The lowest number of people (1.82 percent) found in the mix floor in the study area.

Chapter VII
Population vulnerability

7.1 Vulnerability Context

One of the major objectives of this study is to determine the vulnerability of population of the study area. It is related with the vulnerability of building in different earthquake intensity. Building was classified in to three vulnerability categories that is high, medium and low based on the age, height, shape, cracks, construction material, soft story The number of high vulnerable building has been calculated 33 medium vulnerable 510 and low vulnerable 3032 for details see Khatiwoda 2008. Based on this population living in those buildings are also categories into three levels of vulnerability high, medium and low that is summarized in table 6.1 and details follow.

Table 7.1: Population in Different Vulnerability Classes

Vulnerability class	Morning	Day	Evening	Night	Average	%
High	558	1299	626	608	773	2.40
Medium	6994	6999	7613	7305	7228	22.47
Low	24476	19472	26963	25775	24172	75.13
Total	32028	27770	35202	33688	32173	100.00

Figure 7.1: Population in Different Vulnerability Classes

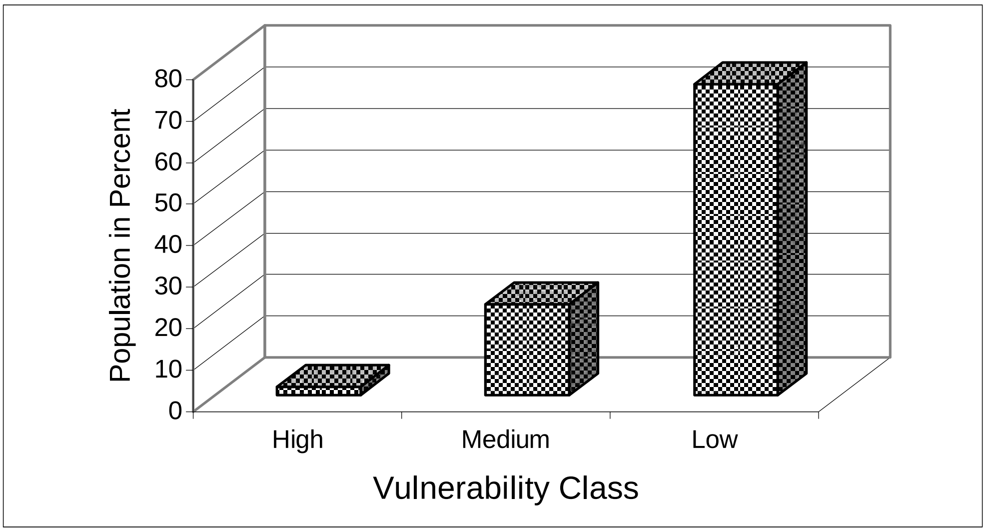


Table 7.1 and figure 7.1 Shows that the average 2.40 percent people of the study area is high vulnerable and 75.13 percent are low vulnerable. In the high vulnerable class maximum vulnerable (1299) people are calculated during day, and medium (7613) and low (26963) in evening time period.

7.1.1 Low Vulnerability

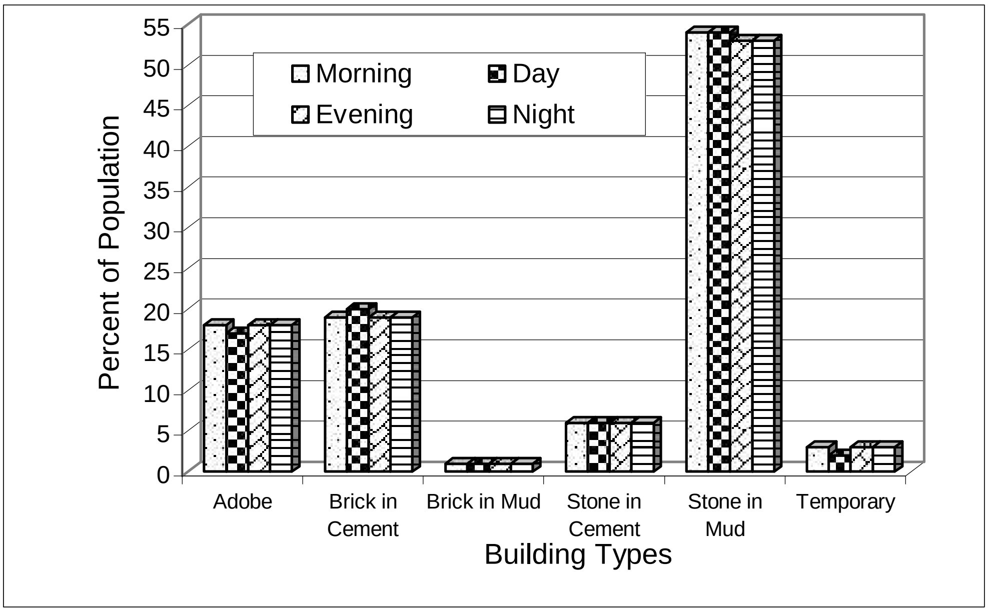
Table 7.2 and figure 7.2 shows the low vulnerability of population. The highest numbers of populations are under the stone in mud building with 53.64 percent in the morning period. Similarly, the lowest numbers of the peoples are under the brick in mud building with 0.71 percent in the day time period. Like this, in the average number, the lowest number of the vulnerable populations is 0.80 percent in brick in mud building and the height number is 53.44 percent in stone in mud building

Table 7.2: Low Vulnerability of Population

Building types	Morning	Day	Evening	Night	Average
Adobe	4424 *(18.07)*	3344 *(17.17)*	4900 *(18.17)*	4761 *(18.47)*	4357 *(18.03)*
Brick in Cement	4694 *(19.18)*	3836 *(19.70)*	5121 *(18.99)*	4882 *(18.94)*	4633 *(19.17)*
Brick in Mud	195 *(0.80)*	138 *(0.71)*	222 *(0.82)*	215 *(0.83)*	193 *(0.80)*
Stone in Cement	1376 *(5.62)*	1233 *(6.33)*	1554 *(5.76)*	1514 *(5.87)*	1419 *(5.87)*
Stone in Mud	13128 *(53.64)*	10447 *(53.65)*	14421 *(53.48)*	13674 *(53.05)*	12918 *(53.44)*
Temporary	659 *(2.69)*	474 *(2.43)*	745 *(2.76)*	729 *(2.83)*	652 *(2.70)*
Total	24476 *(100.00)*	19472 *(100.00)*	26963 *(100.00)*	25775 *(100.00)*	24172 *(100.00)*

Note: Table inside parenthesis represents the percent of the total.

Figure 7.2: Low Vulnerability of Population



7.1.2 Medium Vulnerability

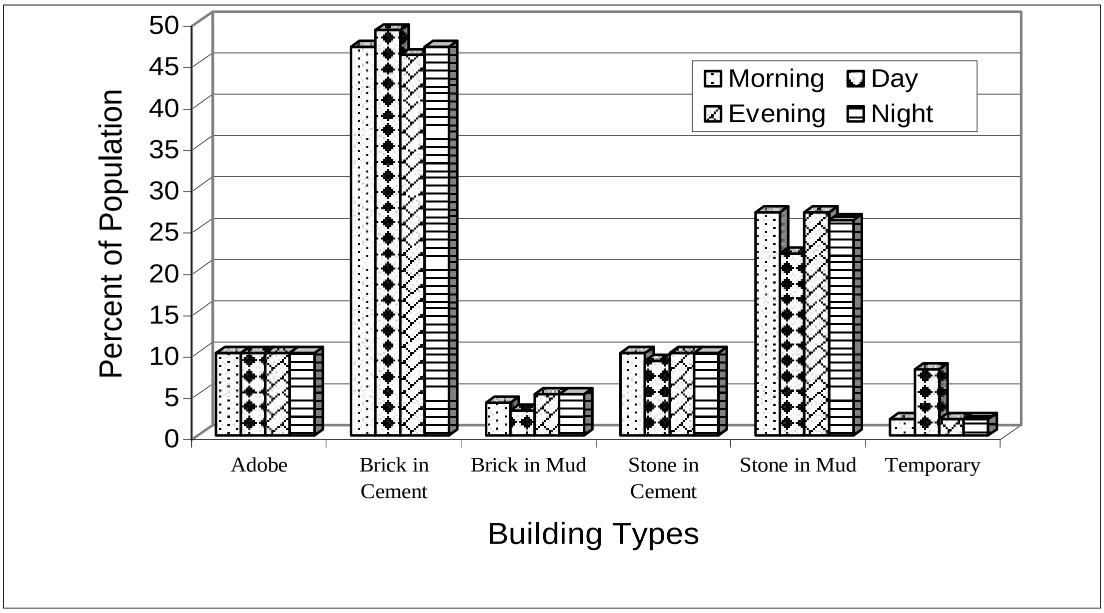
Table 7.3 and figure 7.3 shows 48.74 percent people are the medium classes of vulnerable in the brick in cement building during the day time. Similarly the minimum numbers of vulnerable people are 1.73 percent in temporary building during morning time. In average the highest percent of medium class vulnerable populations are 47.16 in the brick in cement building and the lowest percent is 3.25 in the temporary building.

Table 7.3: Medium Vulnerability of Population

Building Types	Morning	Day	Evening	Night	Average
Adobe	699 *(9.99)*	701 *(10.02)*	763 *(10.02)*	723 *(9.90)*	722 *(9.98)*
Brick in Cement	3270 *(46.75)*	3414 *(48.78)*	3516 *(46.18)*	3435 *(47.02)*	3409 *(47.16*)
Brick in Mud	306 *(4.38)*	194 *(2.77)*	350 *(4.60)*	344 *(4.71)*	299 *(4.13)*
Stone in Cement	690 *(9.87)*	642 *(9.17)*	786 *(10.32)*	767 *(10.50)*	721 *(9.98)*
Stone in Mud	1908 *(27.28)*	1508 *(21.55)*	2058 *(27.03)*	1896 *(25.95)*	1843 *(25.49)*
Temporary	121 *(1.73)*	540 *(7.72)*	140 *(1.84)*	140 *(1.92)*	235 *(3.25)*
Total	6994 *(100.00)*	6999 *(100.00)*	7613 *(100.000*	7305 *(100.00)*	7228 *(100.00)*

Note: Table inside parenthesis represents the percent of the total.

Figure 7.3 Medium Vulnerability of Population



7.1.3 High Vulnerability

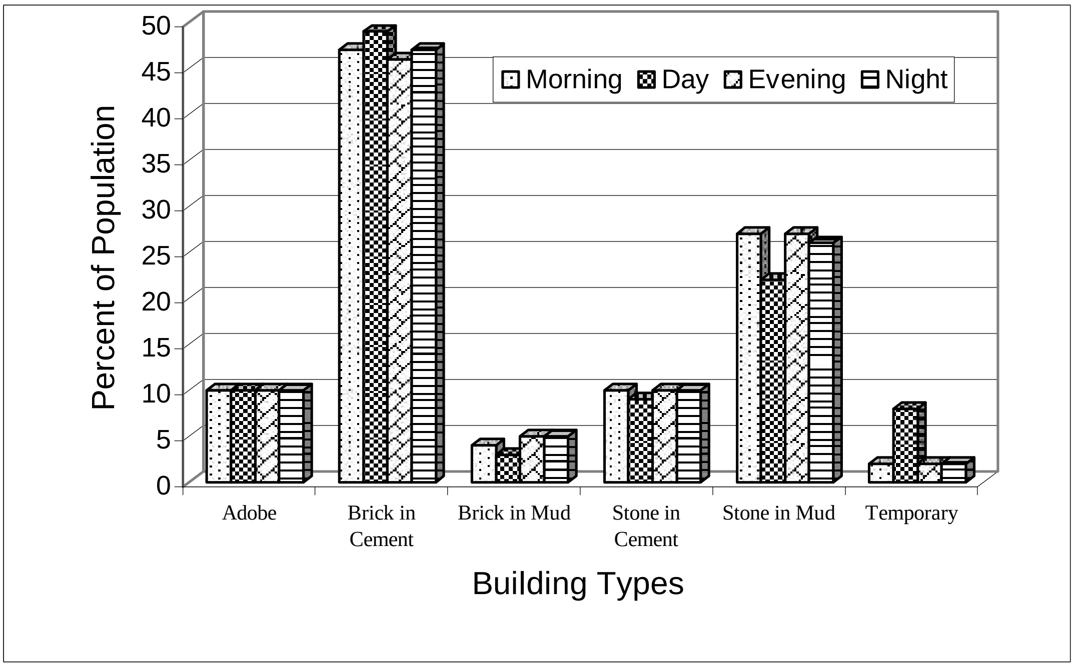
Table 7.4 and figure 7.4 show that in the brick in cement building more than 64 percent people has been calculated high vulnerable during day time. In the brick in mud building the high vulnerability people has been calculated minimum, only 0.62 percent people during day time. In average the maximum vulnerable people are 47.19 percent in brick in cement building and minimum vulnerable people are in 1.75 percent in the brick in mud building.

Table 7.4: High Vulnerability of Population

Building types	Morning	Day	Evening	Night	Average
Adobe	171 *(30.65)*	131 *(10.08)*	186 *(29.71)*	173 *(28.45)*	165 *(21.38)*
Brick in Cement	189 *(33.87)*	840 *(64.67)*	215 *(34.35)*	215 *(35.36)*	365 *(47.19)*
Brick in Mud	14 *(2.51)*	8 *(0.62)*	16 *(2.56)*	16 *(2.63)*	14 *(1.75)*
Stone in Cement	62 *(11.11)*	35 *(2.69)*	72 *(11.50)*	72 *(11.84)*	60 *(7.79)*
Stone in Mud	122 *(21.86)*	285 *(21.94)*	137 *(21.88)*	132 *(21.71)*	169 *(21.86)*
Temporary	0 *(0.00)*	0 *(0.00)*	0 *(0.00)*	0 *(0.00)*	0 *(0.00)*
Total	558 *(100.00)*	1299 *(100.00)*	626 *(100.00)*	608 *(100.00)*	773 *(100.00)*

Note: Table inside parenthesis represents the percent of the total.

Figure 7.4: High Vulnerability of Population



In general the people who are living in the brick in cement building are more vulnerable in the both medium and high classes of vulnerability. In the low class the people who are living in the stone in mud buildings are more vulnerable. In the time base more people are calculated vulnerable during the day time in high and medium classes of vulnerability. In the low class of vulnerability maximum people are vulnerable during the evening time period.

Chapter VIII
Injuries and Casualties

8.1 Introduction

Loss of human lives and injuries are the most important consequence of earthquake, and hence the effort of vulnerability reduction has the priority to keep the number of casualties to minimum (NSET Nepal, 2002 cited in Jimee, 2006). Casualties' estimation is one of the major objectives; this study has estimated the casualty of people who live in Ilam municipality. The casualty is considering only the building vulnerabilities due to different earthquake intensity.

These chapters discuss the probable level of casualties in different earthquake intensity and different severity levels for different time period of the whole day. The population vulnerability are estimated using an empirical relationship developed by HAZUS, between population distribution and building damage or collapse probability due to different earthquake intensity.

The current study has only estimate probable indoor causalities due to building collapse or damage based on the building vulnerability. The probability of building damage and collapse for individual building has been estimated using data on seismic vulnerability of building calculated by Khatiwoda (2008). The casualty ratio was derived from the previous study by Islam (2004) which had basically been developed by HAZUS (1999).

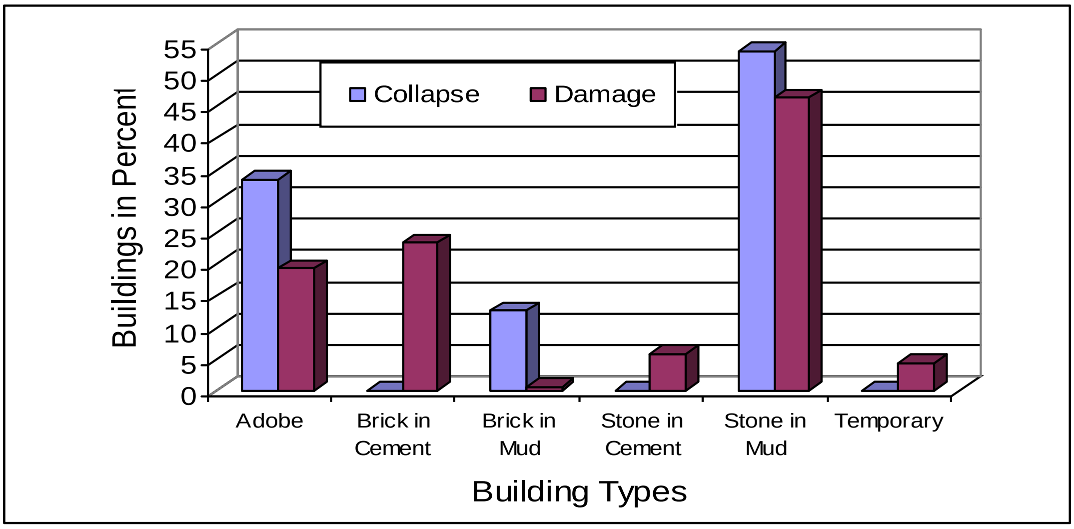
Table 8.1: Probability of Collapse and Damage of Buildings

Building Type	Collapse	%	Damage	%
Adobe	71	33.49	652	19.39
Brick in Cement	0	0.00	785	23.34
Brick in Mud	27	12.74	22	0.65
Stone in Cement	0	0.00	195	5.80
Stone in Mud	114	53.77	1562	46.45
Temporary	0	0.00	147	4.37
Total	212	100.00	3363	100.00

Table 8.1 figure 8.1 shows the probable collapse and damage building of the study area. According to the table the number of total collapse building has been calculated 212 and the damage 3363. Out of total collapse building more

than 53 percent is stone in mud and out of total damage 46.45 percent is stone in mud building.

Figure 8.1: Probability of Collapse and Damage of Buildings



Map 8.1: Ilam municipality: Earthquake Intensity

The map 8.1 shows the location of intensity VII and VIII. In the area of intensity VII there is 392 building and in the intensity VIII there is 3183 buildings. Among them the probable damage building in intensity VIII is 2971 and collapse is 212. In the intensity VII the probability building collapse is 0.

8.1.1 Casualties by Time Period

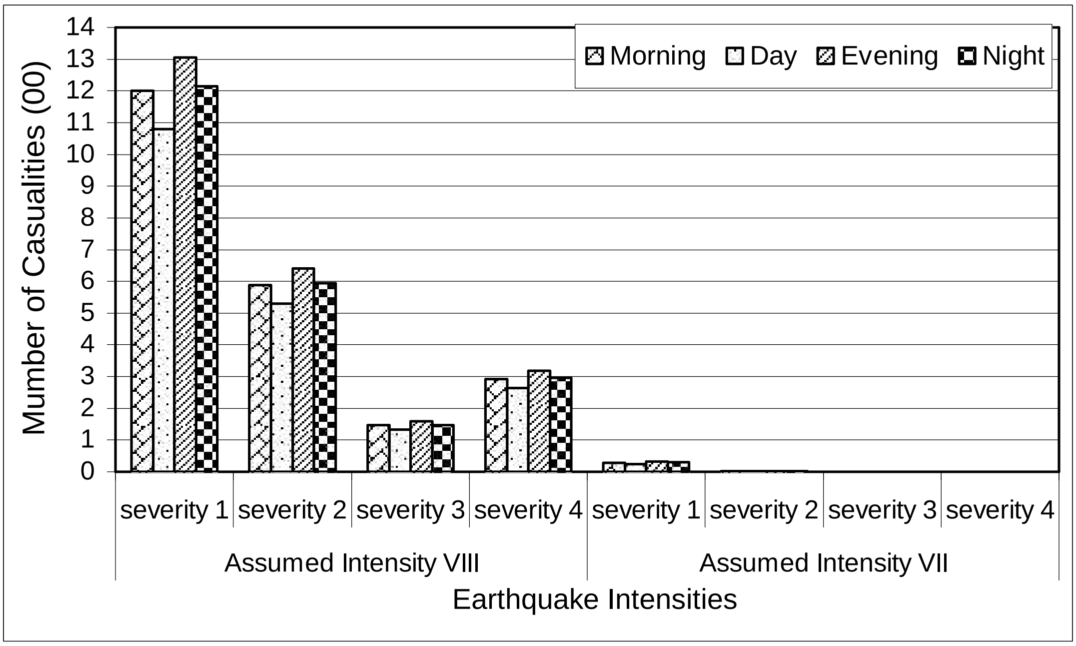
The study has estimated the casualties for different intensity, severity level and different time period of the day. In the study, mainly two cases of building vulnerability were taken i.e. building collapse and building damage. The building vulnerability and casualty are estimated on the basis of intensity VII and VIII only. In this study only the indoor casualties has been estimated. The casualty due to other reason has not been estimated. The casualties may be increased due to other effect as out door casualty and other affect after earthquake for example, fire, landslide, lake out burst, damage of electric wire, telephone wire, and other possible losses. In the study area, the calculated casualties were more in building collapse than building damage. The logic behind this is there is less chances to escape from the building in case of the complete collapse of the building where the victim living in, than damage.

Table 8.2 and figure 8.2 shows that, on the basis of assumption or estimations of casualty in different time period of day and severity level for earthquake intensity VII and VIII. More people are occupy the building in evening, the casualty have calculated in evening is 1273 of severity level 1 in assumed intensity level VIII and 32 of intensity level VII. The calculated casualty of severity level 4 at evening in intensity VIII is 318 and intensity VII is 0. In the intensity VII no high injuries or serious injuries have calculated because no building would be collapse in intensity VII. The serious injuries or mortally injuries i.e. dead have calculated 293 in morning, 263 in day, 318 in evening and 296 in night. The mortally injuries have calculated less in day time. In that calculation the population of schools and campus were not included. The population of campus and schools are calculated in next casualty by building use topic.

Table 8.2: Casualties Due to Different Earthquake Intensities

Earthquake Scenario		Assumed Intensity VII		Assumed Intensity VIII			
Severity Levels	Time	If Building Damaged		If Building Collapsed		If Building Damaged	
		Population	Casualty	Population	Casualty	Population	Casualty
1	Morning	2823	28	2931	1172	26274	29
	Day	2456	24	2634	1054	22680	26
	Evening	3191	32	3183	1273	28828	32
	Night	3111	31	2962	1185	27615	30
2	Morning	2823	3	2931	586	26274	3
	Day	2456	2	2634	527	22680	3
	Evening	3191	3	3183	637	28828	3
	Night	3111	3	2962	592	27615	3
3	Morning	2823	0	2931	147	26274	0
	Day	2456	0	2634	132	22680	0
	Evening	3191	0	3183	159	28828	0
	Night	3111	0	2962	148	27615	0
4	Morning	2823	0	2931	293	26274	0
	Day	2456	0	2634	263	22680	0
	Evening	3191	0	3183	318	28828	0
	Night	3111	0	2962	296	27615	0

Figure 8.2: Casualties Due to Different Earthquake Intensities



Note: With intensity VII the probability building collapse is 0 so no casualty is exceeded.

Generally, the casualties of all severity levels by all intensity were high during evening time than the morning, day, and night. It was due to the people present in market in the commercial building at evening, the farmers return in the residential building at evening. In this calculation of casualty, the school's and campus' population are not included.

8.1.2 Casualty by Building Use

The different types of building and its use have different casualty level in different time period and earthquake intensity. In the commercial building people gather maximum in day and evening time. The same building becomes empty at night. In the schools all students, teachers and other staffs gathered at day time and in morning, evening and night the same schools become empty. In the residential building it found nearly opposite situation. It become highly populated during night. All people come back in home at night from their different working place. In the Nepali culture, people live in home with their family, normally no one live out during night time. It is said that *'Din aafno rat arakako'*. So no people feel safe to live out during night time. Most of the crime happens in night so that people come as possible as in their home or room. In the official buildings maximum people come during day time at 10 am to 5pm. After 5 pm the buildings become empty. In the mix, hospital, hotel and lodge building people found in every time.

In the intensity VII the probability building collapse is 0. The probability of building collapse is only in earthquake intensity VIII. 212 building collapse in earthquake intensity VIII. So in the intensity VII no casualty of severity 4 has been calculated in any time period of day. In the intensity VIII 264 persons were calculated injuries of severity 4 during day time and 296 persons during night. The casualty seem high during night than day because all most residential people stay in the residential building during night and in the day time most people goes out from the building for different work.

Table 8.3: Casualty by Different Building Use

			Res	Com	Office	Mix	Sch	Cam	Hos	H&L
Intensity VII	Severity 1	Day	15	0	42	0	50			0
		Night	30	0	1	0	0			0
	Severity 4	Day	0	0	0	0	0			0
		Night	0	0	0	0	0			0
Intensity VIII	Severity 1	Day	707	160	107	7	285	6	9	0
		Night	1412	12	25	6	0	1	6	1
	Severity 4	Day	143	36	22	1	60	0	2	0
		Night	286	3	5	1	0	0	1	0

Figure 8.3: Casualty by Different Building Use

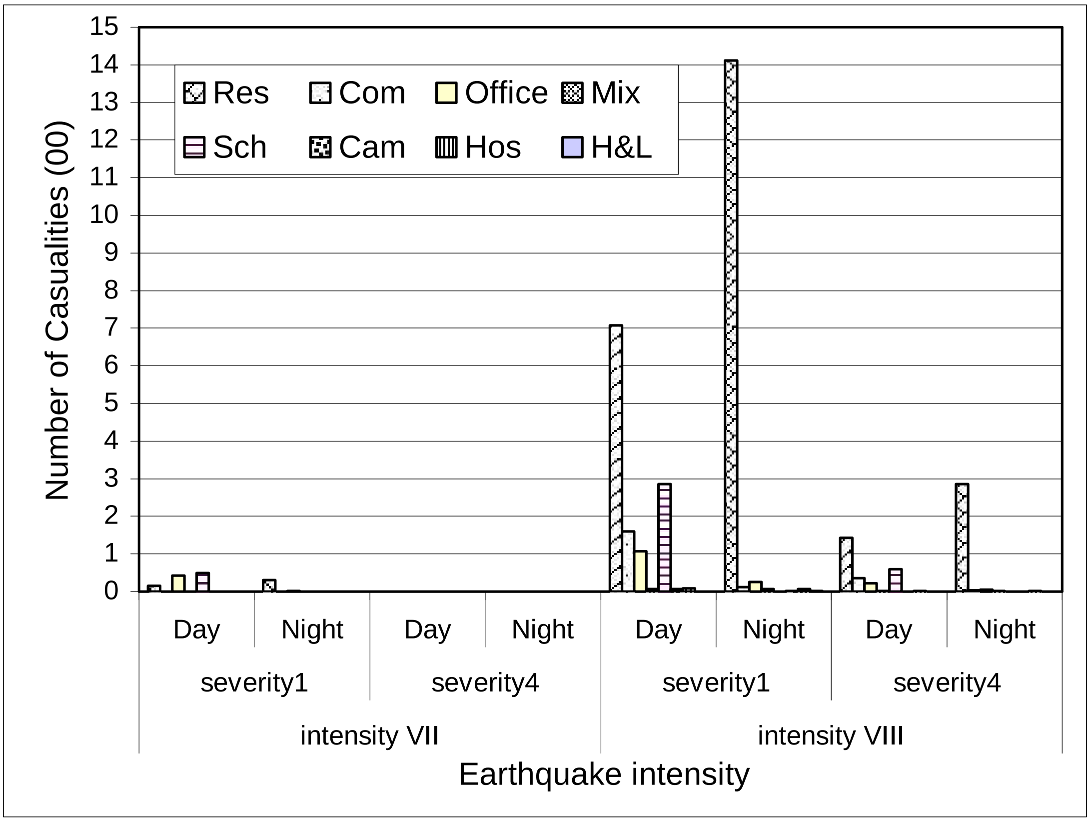


Table 8.3 and figure 8.3 shows that the human casualty is high in intensity VIII in all types of building use. The casualty in residential building is high than other building types in intensity VII and VIII. In both time period in

the intensity VII and severity 1 injure are high in school that is 50 and it is followed by official building that is 42. In the intensity VII no casualty seems during day and night time period of severity 4.

In intensity VIII the casualty in residential building seems high in every severity level than other building use. In the residential building the casualty is high during night than day. All people want to live in the residential building with their family so all people are inside during night time. The casualty of school's students, teachers and other staff is high in severity 1 and 4 than other types of building except residential people during the day time. The casualty in school is 285 of severity 1 and 60 of severity 4 during day time. The casualty of commercial, official, campus, hospital's population is high in severity 1 and 4 during day time than Night time period.

8.1.3 Casualty by Building Types

As the widely realized saying in the field of earthquake, " Earthquake do not kill people unsafe building do", the people living in the vulnerable buildings have more probability to suffer injures of high severity (Jimee 2006) . Vulnerability of building depends on the building types as use of building materials, age of building, building height, geology etc. the population vulnerability depends on the building vulnerability the persons are vulnerable who are living in the weak and vulnerable buildings, though the recent trends is to construct RCC building. In the study area most of the adobe, stone and mud building are used for residential and non residential propose.

In the case of an earthquake with intensity VIII out of total 212 buildings more than 53% stone in mud building and 33% adobe buildings are calculated with high probability of collapse. The stone in cement and brick in cement buildings are found safer in comparison with adobe and stone in mud.

According to the table 7.4 and figure 7.4 in stone and mud building 1465 and 293 persons are injuries of severity 1 and 4 respectively if there is an earthquake with intensity VII and VIII. In the adobe building 385 persons and 86 persons are injures of severity 1 and 4 respectively in intensity VIII. In the case of other types of building 31 in brick in mud buildings, 176 persons in stone in mud buildings were found to be injures of severity 4 in intensity VIII. In the study area there is no any injures of severity 4 in intensity VII. In the intensity VII the casualties of severity 1 have calculate 4, 5, 2, 18 and 1 persons in adobe, brick in cement, stone in cement, stone in mud and temporary building respectively. (See annex: 2 for the total Population).

Table 8.4: Casualty by Building Types

MMI	Building Types	Severity 1	Severity 4
Intensity VII	Adobe	4	0
	Brick in cement	5	0
	Brick in mud	0	0
	Stone in cement	2	0
	Stone in mud	18	0
	Temporary	1	0
Intensity VIII	Adobe	385	86
	Brick in cement	80	0
	Brick in mud	127	31
	Stone in cement	20	0
	Stone in mud	815	176
	Temporary	8	0
	Total	1465	293

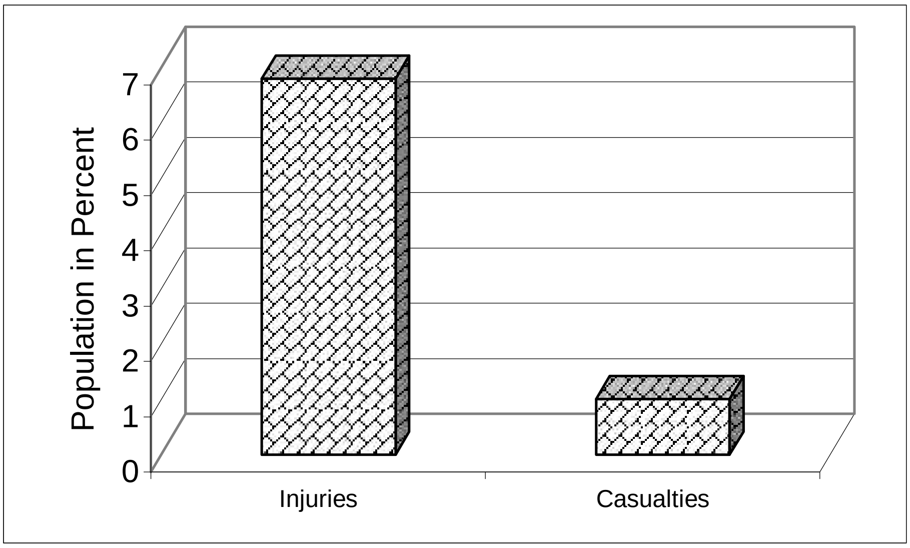
Figure 8.4: Casualty by Building Types

In general in the Ilam municipality the probable injuries population calculated more than 6 percent and the probable casualties 1 percent. In the intensity VII no casualties has been calculated because in intensity VII no building would be collapse. In intensity VIII 2220 persons are calculated probable injuries and 353 casualties which are shown table 8.5 and figure 8.5.

Table 8.5: Probable Injuries and Casualties

	Intensity VII	%	Intensity VIII	%	Total	%
Average Total Population	3399	100.00	26349	100.00	35254	100.00
Probable Injuries	177	5.21	2220	8.43	2397	6.80
Probable Casualties	0	0.00	353	1.34	353	1.00

Figure 8.5: Probable Injuries and Casualties



Chapter IX
Awareness and preparedness

9.1 Introduction

Nepal faces verities of hazards, which combined with the growing population and lack of education and awareness result in very high degree of risk. Nepal is exposed to several types of disasters such as floods, landslide, droughts, wind storms, hail storms, fires earthquake etc. Disasters have been adversely affecting the sustainable development of the nation. Existing disaster management activities in the country is not primarily focused on preventive measures. Earthquakes happen suddenly without any warning and may cause a lager amount of economic and human losses. Human can not stop and control the earthquake, human can only reduce the risk increasing the capacity of potential victims to cape with its impact by preparedness and awareness.

To know the public awareness and preparedness level in the study area 248 residential and 43 non-residential persons have been interviewed. The experience about earthquake have been collect people have different types of experience about privies earthquake.

9.1.1 Knowledge and Awareness

To know the level of public knowledge and awareness, question about earthquake were asked in the residential and non residential floors. The respondents get the knowledge through television and radio then other media. In the case of school many questions related to earthquake were asked to students and teachers. All most all students have knowledge that, during the earthquake people should live out side from the home in safe open place and if they can't go out at that time people should need to go under the table, bed, door and other safe place inside the Building. According to the students they get that knowledge through television and radio. The impact of television and radio found highly effected to all people. The following table 9.1 and figure 9.1 clearly show the level of knowledge and awareness of respondents about earthquake.

Table 9.1: Level of Knowledge and Awareness of Respondents

Question about awareness	Residential	%	Non-residential	%
Awareness Through Radio, T.V.	234	94.35	42	97.67
Information About Organization	84	33.87	14	32.56
Participation in Awareness Program	3	1.21	2	4.65
Old Building Safe	49	19.76	9	20.93
Knowledge About Early Warning	63	25.40	9	20.93
Feel Live in Risk	120	48.39	19	44.19

Source: Field survey 2007.

Figure 9.1: Level of Knowledge and Awareness of Respondents

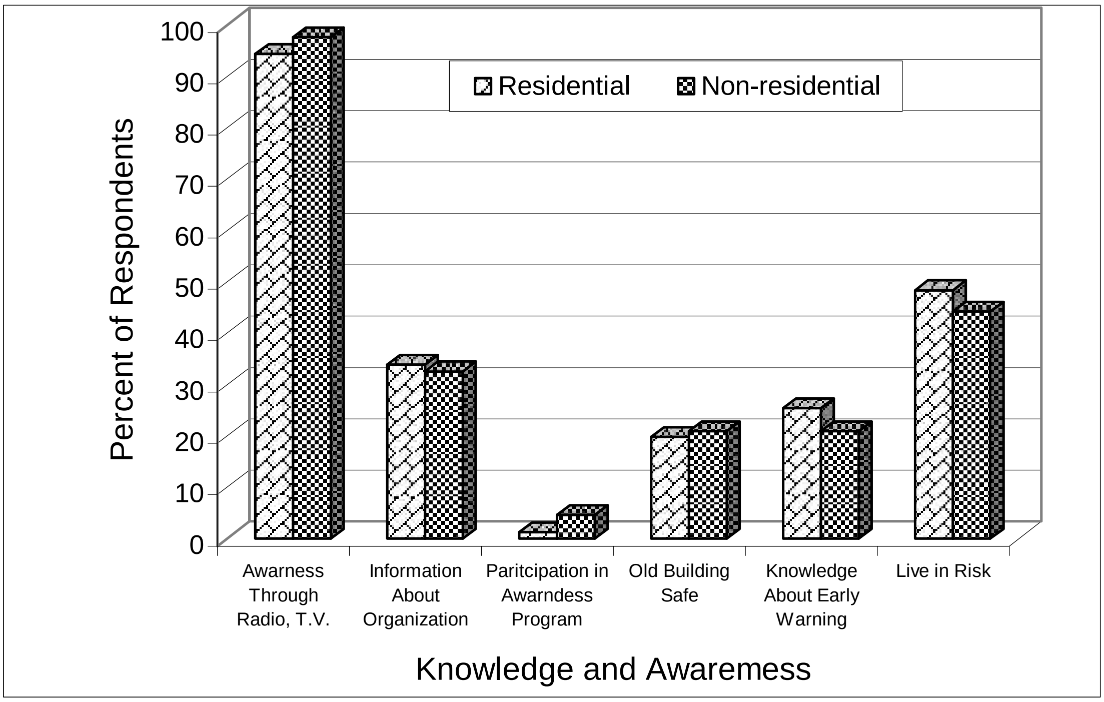


Table 9.1 and figure 9.1 shows that 1.21 percent out of 248 respondents from the residential floors and 4.65 percent of the total 43 respondents from the non residential floors have participated in earthquake awareness program. According to the respondent they can not directly participate in such types of program. The person who are engaged or related with any organization he/she can participate easily in awareness program. Enough awareness programs have not run there. There were only an easy way to get knowledge about earthquake from radio and television. The positive impact of radio and television found highly to both residential and non residential people in the study area. Nearly 94 percent residential respondents and 98 percent of non residential people get

knowledge about earthquake from radio and television. About 34 percent residential and 33 percent non residential respondents know the organization, which help the people during the earthquake to reduce the vulnerability. The role of Nepal Red Cross found less presence in the study area the Nepal Red Cross has given emphasis on the other natural hazard rather than earthquake.

In study area people have not been following the earthquake resistance methods to safe their houses. Large number of houses in the study area is constructed using the local raw materials as stone, mud, wood etc. Adobe buildings are also highly constructed in Ilam. The new trend of building construction is brick and cement is gradually increasing. Mostly governmental offices are found in the old building. The residential and non residential people know the old building be vulnerable in the case of earthquake although they are living there. Business man gives priority first to choose the location of the human gathering point rather than building conditions for the business activities. However the residential and non residential people feel risk their houses; they are compelled to accept this risk. About 80 percent of residential and 79 percent of non residential respondents think that there homes are not safe from the earthquake. Out of total residential and non residential respondents only 17.74 percent from the residential and 23.26 percent from non residential respondents have knowledge about early warning system. Some respondents say that during the earthquake animals' shows the abnormal attitude, the creatures which live inside the ground comes out, fish jump in the water abnormally, water waves seems in the river bank, pond and lake. In the study area 48.39 percent of residential and 44.19 percent from the non residential respondents felt that they are living in risk due to the old and fragile buildings where they are living still.

9.1.2 Preparedness

In the study area both residential and non residential groups are not well prepared for earthquake. Due to the low level of education they don't know how they prepare plan. There is not presence of any types of organization which give the training to the people. They want to get the training but they don't know how they gets, which organization provides training to prepare for earthquake. Due to the low economic condition they are unable to use the safety measures in their building. The following table 9.2 and figure 9.2 show out of 248 respondents about 18 percent of residential and 23 percent of non residential respondents used the safety measures in their building. According to the respondents they are using the pillar, break and cement wall and wide wall as safety measures. More than 37 percent residential and 23 percent of non residential respondents discuss with their family and friends about earthquake especially when they heard the news of large scale earthquake in the world or Nepal. More than 79 percent residential and 81 percent of non residential respondents identify the safe place inside and out side the building. They know the out open place safer than inside the building during the earthquake.

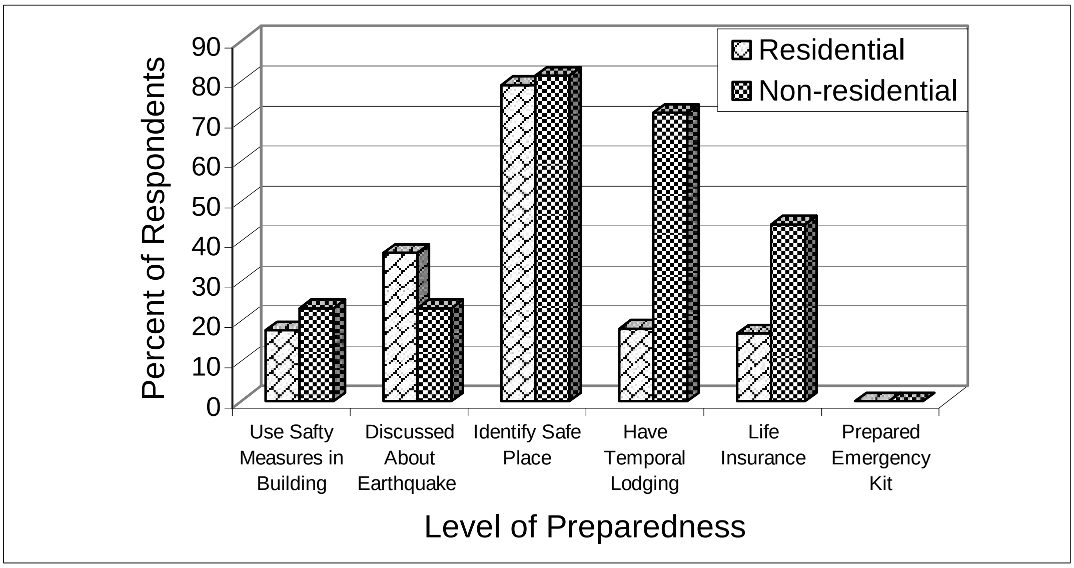
The level of preparedness found low in the residential group than non residential groups. The both group do not have any kinds of emergency kit (first aid, dry food, identity documents water etc.) for the emergency time as earthquake. They don't know how does emergency kit prepared and where that put. So they are not prepared emergency kit. Most of residential respondents have not any other temporal lodging during earthquake. But some residential people who come there being migration, they have their home in the origin place in the non residential group. Most people are living in rent so some of them have temporal lodging in the origin place. Only 16.94 percent of residential people and 44.19 percent of non residential people have the temporal lodging, and 18.15 percent residential and 72.09 percent non residential respondents have done the life insurance. In the case of insurance large number of non residential people are insured. Few residential people are only done the insurance. Mostly 1 or 2 persons of the family did insurance in the both groups. Mainly in the residential and non residential respondents the job holders have insured.

Table 9.2: Level of Preparedness of Respondents

Question about Preparedness	Residential	%	Non-residential	%
Use Safety Measures in Building	44	17.74	10	23.26
Discussed About Earthquake	92	37.10	10	23.26
Identify Safe Place	196	79.03	35	81.40
Prepared Emergency Kit	0	0.00	0	0.00
Life Insurance	42	16.94	19	44.19
Have Temporal Lodging	45	18.15	31	72.09

Source: Field survey 2007

Figure 9.2: Level of Preparedness of Respondents



In general, the level of awareness, knowledge and preparedness for earthquake found very low in the both group. Comparatively the non residential respondent have little high knowledge awareness and preparedness than residential respondent. Due to the education and income they are awarded and prepared than residential respondent.

Chapter X
Conclusion and Recommendations

10.1 Conclusion

The “Population Vulnerability for Earthquake Hazard: A Case Study of Ilam Municipality” has been carried out based on the building vulnerability. The study has been carried out with objectives; to determine the temporal and spatial distribution of population, to determine the temporal and spatial vulnerability of population and to determine probable injuries and casualties of population in time and space.

The study has mainly three components.

- Identifying the vulnerable buildings.
- Estimates of spatial and temporal distribution of population.
- Estimation of population vulnerability and probable casualties based on building vulnerability.

In the Ilam municipality mostly people (53.24%) used the second floor for the different types of activity. More than 60% residential people are used second floor to live or sleep and for the commercial activities first floors are highly used. In the contest of official use more than 95 percent people used the first floor for official activities. In the all time period maximum people are found in the residential floors. In the day time out of 1087people 19.41 and 18.31 percent people are found in the Commercial and official floors respectively. In the study area maximum people (42.57%) use stone in mud building because the stone and mud is local resources which can get easily and it chipper to construct buildings.

In the study area large numbers of people are inside building during the evening than other time period of day. In the residential, hotel and lodge floors large numbers of people are inside the building during the night time period. In the Ilam municipality average 2.40% (773 persons) are calculated the high vulnerability among them 64 percent people is living in the brick in cement building the high vulnerability has been calculated during the daytime period.

Out of 3183 populations the large number of casualties of severity4 (Mortally injured or dead) has been calculated 318 (10%) during evening time period in the earthquake intensity VIII. No casualty has been calculated of severity4 in intensity VII. Out of 2862 persons the highest casualties 286 and 143 persons have been calculated of severity4 during night and daytime respectively in the residential buildings. Out of 590 persons 60 casualties have been calculated of severity4 during day time period in schools' buildings. In the stone in mud buildings' 176 casualties of severity4 have been calculated and nearly half of those 86 casualties have been calculated in adobe building. In general out of 35254 persons 2397 (6.80%) persons are calculated injuries and 353 (1%) persons are calculated casualties.

In the study area the awareness and preparedness for earthquake have not found so well. Very few people are participated in the earthquake awareness program. Most of the respondents have not knowledge about early warning signals. No one respondent have prepared any kinds of emergency kit for earthquake. Some respondents are only insured. Average 95% respondents get the knowledge about earthquake hazard through television and radio. Positive impact of television and radio found highly to students also.

Manly the construction of infrastructure is increasing in the city area or municipalities but they are not following any rules and regulations to protect from the natural disaster. There is lack of information about construction of infrastructure for natural disaster management. No one think about the natural disaster as earthquake while they are constructing the building or infrastructure. They only think how they can build that in low cost.

10.2 Recommendations

In this study the injuries and casualties were estimated using an empirical causality rate used by Islam (2004), which was taken from HAZUS, considering the same rate of injuries and causalities for whole time period of day, all type of age group, both male and female groups and all types of buildings. So this methodology can not draw out the actual causalities.

Therefore it would better to use another methodology to find out the actual injuries and causality of different time period, age groups, genders and buildings type. The study has not covered the outdoor causality of earthquake and other hazard which happen caused by earthquake like fire, land slide, outburst lake etc. So it is recommended for the other researcher to include the outdoor causalities and other natural hazard which happen due to earthquake.

In this study, the economic loss has not been included therefore it is recommended to include the economic losses in the future study.

After analysis the information received from the field survey, the study concluded that the respondents are not well aware and prepared for earthquake. So that it is recommended that the programme of awareness and preparedness should run focusing in the school level and to the local communities.

The role of Nepal Red Cross and other organization has found the less presence in the field earthquake for preparedness and awareness to the local communities and schools that’s why it is strongly recommended to such type of organization to increase their roles towards the local communities and schools.

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Annex 1 (A)

Tribhuvan University, Central Department of Geography, Kirtipur

Population Vulnerability Assessment for Earthquake 'A Case Study of Ilam Municipality'

Floor Wise House Hold Survey for Recidential Building

Ward No. …….. Tole ………….. Block No ……… Form No ……… Date: 2064 / /

Name of Respondent ………………………………… Cast ….………………. Gender…………

1. Family Details

Floor No.	S. N.	Relation with Respondent	Age	Gender	Education	Occupation	Living time	Disability	Remarks

2. Land type

Khet	Bari	Pakho	Others	Total

3. Food sufficient from own production

< 3 months	3-6 months	6-9 months	9-12 months

4. Have your home in any other place?

If yes, where?	Inside the municipality	Out of the municipality

Knowledge and Awareness		
Have You or your family Participate any earthquake awareness programs?		
Have you listened / watched the earthquake awareness programs on radio or T. V.?		
Do you know any organization that can aid you in reducing earthquake vulnerability?		
Do you think your home could be made earthquake safe?		
Do you know about early warning systems?		
Do you thing you live in risk?		

Preparedness		
Have you used any earthquake safety measures in your home?		
Do you discussed with your family reducing earthquake vulnerability?		
Have you identified a safe place in side and out side of your home if here is an earthquake?		
Have you prepared any emergency kit (First aid, Dry food, Identity documents, Water etc.)?		
Incase of disaster do you have temporal lodging?		
Have you do any bank balance		
Have you and your family life insurance?		

How many Persons have receive training							
Disaster prevention		Emergency preparedness		First-Aid		Other	

Whom do you blame for the losses (lives and property) due to an earthquake?									
God		Government		Engineer		Municipality		Own	

5. How much far health services or hospital from your home?
....

6. Have your any experience about earthquake in your life?
   If yes what did you do during this time ....

7. How much do you earn annually Rs. ……………………………………

Annex: 1 (B)

Tribhuvan University, Central Department of Geography, Kirtipur

Population Vulnerability Assessment for Earthquake 'A Case Study of Ilam Municipality'

Floor Wise House Hold Survey for Non- Residential Building

Ward No.		Tole		Block No.		Floor No.		Form No.		Date: 2064 / /

Population Distribution

In Average How Many Persons Stay Here During This Time

Morning (5am-9am)			Day (9am-5pm)			Evening (5pm-9pm)			Night (9pm-5am)		
Age Group	Male	Female	Age Group	Male	Female	Age Group	Male	Female	Age Group	Male	Female
Below 10			Below 10			Below 10			Below 10		
11 to 15			11 to 15			11 to 15			11 to 15		
16 to 60			16 to 60			16 to 60			16 to 60		
61 to 69			61 to 69			61 to 69			61 to 69		
Above 70			Above 70			Above 70			Above 70		

Knowledge and Awareness

Have You Participate any earthquake awareness programs?		
Have you listened / watched the earthquake awareness programs on radio or television?		
Do you know any organization that can aid you in reducing earthquake vulnerability?		
Do you think old building could be made earthquake safe?		
Do you know about early warning systems?		
Do you thing you live in risk?		

Preparedness

Have you used any earthquake softie measures in your building?		
Do you discussed with each other reducing earthquake vulnerability?		
Have you identified a safe place in side and out side of this building if here is an earthquake?		
Have you prepared any emergency kit (First aid, Dry food, Identity documents, Water etc.)?		
Have you done life insurance?		
Incase of disaster do you have temporal lodging?		

How many Persons have receive training

Disaster prevention		Emergency preparedness		First- Aid		Other	

Whom do you blame for the losses (life's and property) due to an earthquake?

God		Government		Engineer		Municipality		Own	

Annex: 2

Population in Probable Damage Building in Intensity VII (According to Building Type)

	Adobe	Brick in cement	Brick in mud	Stone in cement	Stone in mud	Temporary
Morning	384	433	0	170	1786	50
Day	372	426	0	182	1444	32
Evening	441	492	0	192	2009	57
Night	431	480	0	186	1958	56

Population in Probable Damage Building in Intensity VII (According to Building Uses)

	Residential	Commercial	Office	Mix	School	Campus	Hospital	Hotel & Lodge
Morning	2657	0	162	4	0	0	0	0
Day	1528	0	421	3	504	0	0	0
Evening	3026	0	162	3	0	0	0	0
Night	3026	0	97	2	0	0	0	0

Population in Probable Damage Building in Intensity VIII (According to Building Type)

	Adobe	Brick in cement	Brick in mud	Stone in cement	Stone in mud	Temporary
Morning	4066	7720	195	1958	11605	730
Day	2987	7664	138	1728	9181	982
Evening	4489	8360	222	2220	12709	828
Night	4360	8052	215	2167	12008	813

Population in Probable Collapse Building in Intensity VIII (According to Building Type)

	Adobe	Brick in cement	Brick in mud	Stone in cement	Stone in mud	Temporary
Morning	844	0	320	0	1767	0
Day	817	0	202	0	1615	0
Evening	919	0	366	0	1898	0
Night	866	0	360	0	1736	0

Population in Probable Damage Building in Intensity VIII (According to Building Uses)

	Residential	Commercial	Official	Mix	School	Campus	Hospital	Hotel & lodge
Morning	23456	1386	723	264	0	359	58	28
Day	13411	1619	1870	176	4866	614	96	28
Evening	26760	925	723	221	0	59	75	65
Night	26744	120	435	134	0	59	58	65

Population in Probable Collapse Building in Intensity VIII (According to Building Uses)

	Residential	Commercial	Official	Mix	School	Campus	Hospital	Hotel & lodge
Morning	2507	310	83	19	0	0	12	0
Day	1432	360	219	13	590	0	20	0
Evening	2862	207	83	15	0	0	16	0
Night	2862	27	52	9	0	0	12	0

Annex: 3
Descriptions of Building Types

Adobe	These buildings are mainly made of sun dried brick with mud. They are found mostly in the urban periphery and some can still be found in urban area.
Brick in Cement	These building are made by fried brick with cement. This is the most common type of building in the urban area. Most of such buildings were constructed after 1988 in the study area.
Brick in Mud	These buildings are made by fried brick with mud. A few such types of buildings are found in the study area.
Wooden	These types of building were made by timber.
Stone in Mud	These types of building are most common type of building in rural area. There are constructed by stone with mud.
Temporary	It is also a type of building tin rural area. These types of building were made by bamboo and mud. It is assumed as safety from earthquake.

Annex: 4
Descriptions of Building Uses

Uses types of Buildings	Descriptions
Residential	The buildings which are using for residential purpose.
Commercial	The buildings which are using dominantly for commercial activities or purpose.
Official	The buildings which are using for official activities.
Mix	The buildings which are using for residential, commercial, official and other purpose (where are not any ones dominant uses).
Hotel and Lodge	The buildings which are using for Hotel and Lodges.

Annex: 5(A)
Sampled Building of Ward No. 1 and 2: Ilam Municipality

Annex: 5(B)
Sampled Building of Ward No. 3: Ilam Municipality

Annex: 5(C)
Sampled Building of Ward No. 4: Ilam Municipality

Annex: 5(D)
Sampled Building of Ward No. 5: Ilam Municipality

Annex: 5(E)
Sampled Building of Ward No. 6: Ilam Municipality

Annex: 5(F)
Sampled Building of Ward No. 7: Ilam Municipality

Annex: 5(G)

Sampled Building of Ward No. 8: Ilam Municipality

Annex: 5(H)

Sampled Building of Ward No. 9: Ilam Municipality

Annex: 6
Global Seismic Hazard Map

Annex: 7 (A)
Seismic Hazard Map of Nepal

Annex: 7 (B)
Seismic Hazard Map of Nepal

Annex: 8
Some Photo Features during Field Work

Researcher is filling the research questionnaires with respondents.

Researcher is taking information about awareness and preparedness with elder experienced respondents.