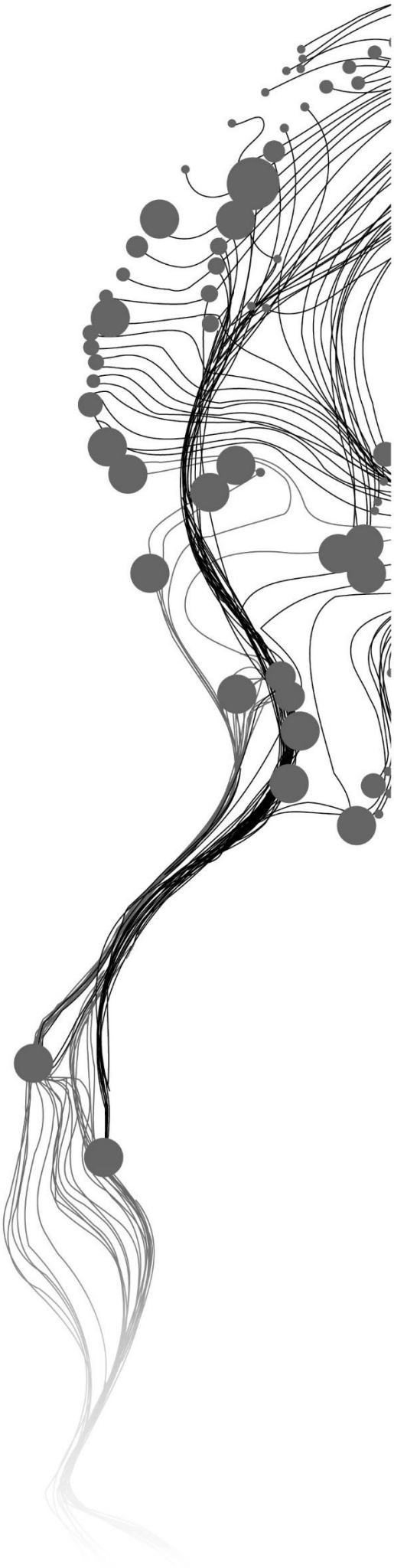

# IMPROVING COMMUNITY RESILIENCE IN EARTHQUAKE DISASTER WITH INCREASED ACCESS TO GEO-INFORMATION

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May, 2014

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# IMPROVING COMMUNITY RESILIENCE IN EARTHQUAKE DISASTER WITH INCREASED ACCESS TO GEO-INFORMATION

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Enschede, The Netherlands, [May, 2014]

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# ABSTRACT

Human beings have been experiencing earthquake disasters since a long time. These cannot be avoided and need to be tackled successfully. However, its impact can be minimized by developing a resilient society. In simple terms, resilience is about bouncing back to the original position after being hit by a disaster. There are various ways by which resilience can be developed but one of them is by having access to the geo information. The main objective of the research is to analyse the present status of geo-information relevant for community resilience. The sub-objectives are firstly to perform an in-depth analysis of the current role of geo-information products and services, and related sharing practices. Secondly, it is to determine the gap between the desirable geo-information and currently available geo-information products and services and related sharing practices at each institutional level and the in earthquake disaster risk management phases and reflect on the roles of geo-information for community resilience.

The research has been carried out in one of the traditional cities of Nepal, Patan in Ward no 12 which is adjoining the World Heritage monument zone of the Kathmandu Valley World Heritage Site. Qualitative research method has been used. In this case, closed, one-to-one interviews have been taken with the key informants of National Government, Local Government, I/NGOs. Similarly, open, one-to-one interviews were taken with the formal and informal community based organizations. A total of 99 randomly selected households and 15 trained (DRR awareness training) individuals were also surveyed with the help of the prepared questionnaires. The data collection was done through primary and secondary sources.

The result in this research is the finding of gap of available geo-information in the case study and the optimal status geo-information found in the literature. The geo-information products and services from the National Government, Local Government, humanitarian Organizations, NGO/INGOs, formal, informal communities, households as well as individuals are analysed and discussed. The discussion concludes with the informal organization such as *Guthi* which is capable to fill in the gap of accessibility of geo-information products and services. People get the information easily from the informal community based organization like *Guthi* whose history goes back to more than 1500 years. So it has been recommended to make use of this traditional informal community based institution for having a resilient community.

**Keywords:** Community Resilience, Disaster Risk Reduction, Geo-information Products and Services, Preparation, Coping, Recovery, Adaptation, Institutions

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Sweta Pokharel

# TABLE OF CONTENTS


**1. INTRODUCTION** ..... 4
- 1.1. General ..... 4
- 1.2. Background ..... 4
- 1.3. Research Problem ..... 5
- 1.4. Justifications ..... 5
- 1.5. Research Objectives ..... 5
- 1.6. Research Questions ..... 5
- 1.7. Research Framework ..... 6
- 1.8. Research Design ..... 7
- 1.9. Study Area ..... 8
- 1.10. Thesis Structure ..... 8

**2. Literature study** ..... 11
- 2.1. Disaster and Earthquake Disaster ..... 11
- 2.2. Resilience ..... 14
- 2.3. Geo-information ..... 21
- 2.4. Conclusion ..... 28

**3. Framework of Community Resilience and Lessons learnt in Earthquake Disaster** ..... 29
- 3.1. Geo-information in Earthquake Diasater ..... 29
- 3.2. Framework of Community Resilience ..... 30
- 3.3. Production, Sharing and Use of Products and Services for Disaster Risk Management Cycle ..... 30
- 3.4. Products and Services used in Haiti (2010) and Wenchaun (2008) Earthquake ..... 40
- 3.5. Conclusion ..... 44

**4. Field Work Process** ..... 45
- 4.1. Site Selection ..... 45
- 4.2. Pre-Fieldwork ..... 46
- 4.3. Fieldwork ..... 52
- 4.4. Post Fieldwork ..... 53
- 4.5. Constraints during field work and data collection ..... 53
- 4.6. Conclusion ..... 54

**5. Analysis and Results of Community Resilience** ..... 55
- 5.1. Review of Collected Data ..... 55

Knowledge Management and Communication: An open house for knowledge initiatives (ICIMOD, 2008 - 2014b) ..... 56
- 5.2. Overview of the types of Geo-information Produced, Shared and Used ..... 62
- 5.3. Analysis at National Government level ..... 62
- 5.4. Analysis at Local Government level ..... 63
- 5.5. Analysis at INGO and NGO level ..... 63
- 5.6. Analysis at INGO level ..... 64
- 5.7. Analysis at Community level ..... 65
- 5.8. Analysis at Individual level ..... 66
- 5.9. Conclusion ..... 66

**6. Discussions** ..... 67
- 6.1. Discussions on Community Resilience in the National Government Level ..... 67
- 6.2. Discussions on Community Resilience in the Local Government Level ..... 69
- 6.3. Discussions on Community Resilience in the Humanitarian and INGO Level ..... 70
- 6.4. Discussions on Community Resilience in the NGO Level ..... 71

6.5. Discussions on Community Resilience in the Community Level ..... 72
6.6. Discussions on Community Resilience in the Informal Community Level ..... 74
6.7. Reflection on the Gaps of the Available compared with the Optimal status of Geo-information ..... 74
- National Government level ..... 74
- Local Government level ..... 75
- INGO and NGO level ..... 75
- Community level ..... 76
- Individual level ..... 76
6.8. Conclusion ..... 76
**7. Conclusions and Recommendations** ..... 77
7.1. Findings ..... 78
7.2. Recommendations ..... 78
7.3. Further Research ..... 78

# LIST OF FIGURES

Figure 1 Framework of Community Resilience ..... 6
Figure 2 Case Study Area: Patan, Lalitpur, Nepal.source:http://www.un.org.np/maps/district-maps/central/Lalitpur.pdf) ..... 8
Figure 3 The disaster management cycle (source: PSC Forum, www.publicsafetycommunication.eu) ..... 12
Figure 4 Disaster Cycle and its development through time (Iglesias, 2005) ..... 13
Figure 5 The Disaster Risk Management Cycle (DRMC) ..... 13
Figure 6 The Resilience Triangle ..... 15
Figure 7 Properties of resilience (Adger, 2000) ..... 18
Figure 8 A hypothetical trajectory of resilient and less resilient community (Modified from Zhang) ..... 21
Figure 9 The Disaster Risk Management Cycle ..... 28
Figure 10 About Kathmandu Living Labs (KLL, 2014) ..... 30
Figure 11 Geo-Eye image shows Port-au-Prince, Haiti after a 7.0-magnitude earthquake struck the area on Jan. 12, 2010. The image clearly shows extensive damage, roads covered with debris from collapsed structures, and people crowded in the streets and public places such as sports fields and stadiums. The image was taken by the GeoEye-1 satellite from 423 miles in space at 10:27 a.m. EST on Jan. 13, 2010 .. 40
Figure 12 Geo-Eye image shows Port-au-Prince, Haiti after a 7.0-magnitude earthquake struck the area on Jan. 12, 2010 ..... 41
Figure 13 Unmanned airplane image of Wenchaun County (Yingxiu town), Sichuan Province, 14th May 2008, NDRCC (S. Li, Fan, Yang, & Wang, 2010) ..... 42
Figure 14 Selected area for case study ..... 45
Figure 15 Case study area with sample point ..... 46
Figure 16 Disaster Management in Nepal (Source: Nepalese Journal on Geoinformatics- 11, 2012) ..... 48
Figure 17 Community volunteers with NSET ..... 60
Figure 18 Percentage of trained individuals' membership in different social institutions ..... 61
Figure 19 Percentage of households' membership in different social institutions ..... 61

# LIST OF TABLES

Table 1 Elements and Entities for Community Resilience....30
Table 2 Geo-information production, shared and used among various Institutions in Preparation phase of Resilience....32
Table 3 Geo-information production, shared and used among various Institutions in Coping phase of Resilience....34
Table 4 Geo-information production, shared and used among various Institutions in Recovery phase of Resilience....36
Table 5 Geo-information production, shared and used among various Institutions in Adaptation phase of Resilience....38
Table 6 Earthquakes in Nepal....45
Table 7 Ward, Research Population and Sample Households....46
Table 8 Institutions selected for interviews....47
Table 9 List of geo-information products and services within various levels of institutions....49
Table 10 Specific Review of DRR and Geo-information related activities for Community Resilience....55

# LIST OF APPENDICES

Appendix 1. Summary of the Hyogo Framework for Action 2005-2015
Appendix 2. Nine minimum characteristics of disaster resilient community in Nepal
Appendix 3. Minimum Characteristics of Development Process
Appendix 4. Interview with institutions, study area and buildings
Appendix 5. GIS Map of 75 Districts (Lalitpur Administrative Boundary, Road Network)
Appendix 6. Map of Kathmandu Valley with Evacuation Shelters and Study Area indicated
Appendix 7. Map of Study Area, Ward no. 12, Patan Lalitpur with Security related legend
Appendix 8. Map of Study Area, Ward no. 12, Patan Lalitpur with Disaster related services
Appendix 9. Seismic zoning Map of Nepal
Appendix 10. Earthquake Hazard Map of Nepal
Appendix 11. Earthquake Intensity Map of 1934 Earthquake in Kathmandu Valley
Appendix 12. Earthquake Intensity Map of 1934 Earthquake in Kathmandu Valley
Appendix 13. Identified Open Spaces in Kathmandu Valley
Appendix 14. Identified Open Spaces (Lalitpur Sub-Metropolitan City)
Appendix 15. Identified Potential Evacuation Sites (Lalitpur Sub-Metropolitan City)
Appendix 16. Population Holding Capacity of Identified Open Spaces in Kathmandu Valley
Appendix 17. Size of Identified Open Spaces in Kathmandu Valley
Appendix 18. Usable area of Identified Open Spaces in Kathmandu Valley
Appendix 19. Potential Ground Water Yield Zoning (Lalitpur Sub-Metropolitan City)
Appendix 20. Existing Deep Tube Wells (Lalitpur Sub-Metropolitan City)
Appendix 21. Distance between Recommended Deep Tube Wells and the Proposed Evacuation Sites (Lalitpur Sub-Metropolitan City)
Appendix 22. Building Age of the Urban Regeneration Pilot Site (Kathmandu Metropolitan City, Ward No. 21 &23)
Appendix 23. Ghorahi Municipality (South Ghorahi Earthquake Scenario, Mg. 7.2.)
Appendix 24. Existing Water Supply System (Preliminary Results) Mapping of VDC, Nepal
Appendix 25. Mapping of VDC, Nepal
Appendix 26. CBDRR in Kathmandu District Chapter
Appendix 27. CBDRR Program Implementing VDCs and Wards in Kathmandu Valley
Appendix 28. School Earthquake Safety Program in Kathmandu Valley
Appendix 29. OpenStreetMaps
Appendix 30. OpenStreetMaps of Study Area (Source: Kathmandu Living Labs)
Appendix 31. OpenStreetMaps of Study Area (sattelite layer) (Source: Kathmandu Living Labs)
Appendix 32. Earthquake Mortality Risk Map
Appendix 33. GeoMountain, GeoPortal for Earthquake Emergency Management and Response System for Kathmandu Valley
Appendix 34. Interview Questionnaire (Community/Individuals)
Appendix 35. Interview Questionnaire (Organizations)

# LIST OF ABBREVIATIONS AND ACRONYMS

| | |
|---|---|
| AMIS | Agriculture Management Information System |
| CBDP | Community Based Disaster Preparedness |
| CBDRR | Community Based Disaster Risk Reduction) |
| CBOs | Community Based Organizations |
| CCA | Climate Change Adaptation |
| CoRD | Center of Resilience Development |
| CDMC | Community Disaster Management Committee |
| CDRC | Central Disaster Relief Committee |
| CDRI | Community Disaster Resilience Index |
| DAO | District Administrative Office |
| DCs | District Chapters |
| DDC | District Development Committee |
| DDRC | District Disaster Relief Committee |
| DDRMP | District Disaster Risk Management Plan |
| DEM | Digital Elevation Model |
| DHM | Department of Hydrology and Meteorology |
| DIMS | Disaster Information Management System |
| DM | Disaster Management |
| DMC | Disaster Management Committes |
| DMG | Department of Mines and Geology |
| DPNet | Disaster Prevention Network |
| DPRP | Disaster Preparedness and Response Plan Framework |
| DRM | Disaster Risk Management |
| DRMC | Disaster Risk Management Committee |
| DRMC | Disaster Risk Management Cycle |
| DROP | Disaster Resilience of a Place |
| DRR | Disaster Risk Reduction |
| DRRN | Disaster Risk Reduction in Nepal |
| DTM | Digital Terrain Model |
| DUDBC | Department of Urban Development and Building Construction |
| EO | Earth Observation |
| ERRP | Earthquake Risk Recovery Programme |
| EWS | Early Warning Systems |
| FGD | Focused Group Discussion |
| GDACS | Global Disaster Alert and Coordination System |
| GIS | Geographic Information System |
| GNSS | Global Navigation Satellite System |
| GPS | Global Positioning System |
| HFA | Hyogo Framework of Action |
| HH | Household |
| HIC | Humanitarian Information Centre |
| ICIMOD | International Center for Integrated Mountain Development |
| IFRC | International Federation of Red Cross Movement |
| IO | International Organizations |
| INGO | International Non-Government Organization |
| INSPIRE | Infrastructure for Spatial Information in Europe |
| ISDR | International Strategy for Disaster Reduction |
| ISRO | Indian Space Research Organization |
| ITHACA | Information Technology for Humanitarian Assistance, Cooperation and Action |
| JAXA | Japan Aerospace Exploration Agency |
| KLL | Kathmandu Living Labs |

| | |
|---|---|
| KVDTC | Kathmandu Valley Town Development Committee |
| LBS | Location based services |
| LCMMS | Low Cost Mobile Mapping System |
| LDRMC | Local Disaster Risk Management Committee |
| LDRMP | Local Disaster Risk Management Planning |
| LIDAR | Light Detection and Ranging |
| LSMC | Lalitpur Sub Metropolitan City |
| MCEER | Multi-Disciplinary Center for Earthquake Engineering Research |
| MoAD | Ministry of Agriculture Development |
| MODIS | Moderate-resolution satellite |
| MoFALD | Ministry of Federal Affairs and Local Development |
| MoHA | Ministry of Home Affairs |
| M&E | Monitoring & Evaluation |
| NCDM | Nepal Center for Disaster Management |
| NDRCC | National disaster Reduction Centre |
| NGII | National Geographical Information Infrastructure |
| NGIS | National Geographical Information System |
| NGO | Non-Government Organization |
| NRCS | Nepal Red Cross Society |
| NSDRM | National Strategy for Disaster Risk Management |
| NSET | National Society for Earthquake Technology |
| OGC | Open Geospatial Consortium |
| OpenDRI | Open Data for Resilience Initiative |
| OWS | OpenWeb Services |
| OSM | Open source mapping |
| PDNA | Post Disaster Needs Assessment |
| PPGIS | Public Participatory GIS |
| RS | Remote-sensing |
| SAR | Search & Rescue |
| SBSM | State Bureau of Surveying and Mapping |
| SDI | Spatial Data Infrastructures |
| SPIDER | Space-Based Information for Disaster Management and Response |
| SWOT | Strength, Weakness, Opportunity and Threat |
| TOSE | Technical, Organizational, Social, and Economic |
| UAV | Unmanned Aerial Vehicle |
| UDRM | Urban Disaster Risk Management |
| UN | United Nations |
| UNDP | United Nations Development Project |
| UNISDR | United Nations International Strategy for Disaster Reduction |
| UN-SPIDER | United Nations Space-based Information for Disaster Management in Emergency Response |
| UN WFP | United Nations World Food Programme |
| USGS | United States Geological Survey |
| VCA | Vulnerability and Capacity Assessment |
| VDC | Village Development Committee |
| VGI | Volunteered Geographic Information |
| WDMC | Ward Level Disaster Risk Management Committee |
| WFP | World Food Programme |
| WMS | Web Map Servers |
| xUAV | Grassroots Unmanned Aerial Vehicle |

# 1. INTRODUCTION

## 1.1. General

There is a worldwide rise in the natural disasters (J. C. Gaillard & Texier, 2010). Among the types of natural disasters, earthquakes, tsunamis and volcanic eruptions are geophysical which occur as a result of anomalies in the surface or subsurface of the earth (Van Westen, 2012). Earthquakes are critical in terms of destruction and significant in terms of the increase in the damage around the world (Allen, 2006) creating devastating effects to the people and infrastructure (James, 2008).. These effects could however be minimized through Disaster Risk Management (Orhan. Altan et al., 2013) responding to impacts of the hazardous events and vulnerable societies (Van Westen, 2012). These vulnerable societies are the communities which function and adapt in the aftermath of disasters (Norris, Stevens, Pfefferbaum, Wyche, & Pfefferbaum, 2008). Such communities however lack resilience to respond positively towards the adverse effects (Sonn & Fisher, 1998). Among many others, the strength of relationships among the sectors and groups of the community as well as the decisions of the government policy evaluate its resilience (Knight, 2012).

Disaster Risk Management is one among the several applications in the concept of resilience (Siambabala Bernard Manyena, 2006; Norris et al., 2008). The application of geo-information in Disaster Risk Management is becoming crucial to improve its phases namely mitigation, preparedness, relief and response, recovery and reconstruction. The use of geo-information technologies, systems, approaches, products, imagery, data, information and their integration have benefited immensely in the earthquake of Pakistan (2005), Indonesia (2006), Haiti (2010) and Japan (2011) (Orhan Altan, Backhaus, Boccardo, & Zlatanova, 2010). Various international efforts have been undertaken to build frameworks for disaster reduction amongst which the recent one is the Hyogo World Conference on Disaster Reduction held in Kobe, Japan, 2005. (Susan L. Cutter et al., 2008). It agrees with (Waugh, 2000), who considers that disaster risk management should strive to resist disaster and develop resilient communities.

## 1.2. Background

Disaster considered as an act of god is interpreted in scientific terms as the act of nature and respectively with time as an act of society. A social event manifested by the behaviours of a group of dysfunctional human beings combined with the location in seismic zone results in a potential disaster (Voogd, 2004). The significance of the vulnerability and capacity to cope with the impact is equal to the significance of the occurrence of the earthquake (Ahrens & Rudolph, 2006). Resilient activities such as pre-event risk modelling, post-event mitigation and emergency response throughout the disaster risk management cycle reduces the impact of disaster (Eike, Beverley, Friedemann, & Walter, 2010). Organizational and social phenomenon are among many concepts of resilience (Kathleen J. Tierney, 2003). The resilience to disasters should be made at different scales spatially such as local, regional, national etc (Zhou, Wan, & Jia, 2010).

Agencies related to government and non-government work on scenarios within administrations, organizations and domains. They are located within the local, regional, national and international levels fed with information from various interventions of sources and systems. For eg: the government in local administrations along with their emergency services and utilities including the organizations volunteering operate as per the roles in their level (Chris & Mark, 2010).The response from the Haitian government which faced the impacts of the devastating earthquake of 2011 included a struggling institution (Margesson & Taft-Morales, 2010, February). The root cause for disaster susceptibility is the institutional failure which can be reduced by making well-structured and strong institution (Ahrens & Rudolph, 2006). Therefore, an obligation arises to collaborate among agencies and nations (Cygan & Patterson, 2010).

## 1.3. Research Problem

There occurs an enormous information flow within the administrative bodies and operational services during recovery phase of disaster compared to the normal days. They use a larger number of geo-information and systems. However, they do not fully supply for combining, analysing and visualizing data. The use of geo-information remains within individual organizations (Diehl & Hiede, 2005).

The research problem is the analysis of the gap between available geo-information for community resilience and the geo-information that should be optimally available using best practices case studies from literature. The information is both spatial and non-spatial and the institutions are the disaster risk management structure. The information is categorized within disaster risk management cycle and resilience.

## 1.4. Justifications

The quality of disaster management depends upon the information needed for decision making. It requires precise, accurate and actual data on-time. This is contrary to the areas having unexpected disasters and absence of base dataset as the data processing depends upon the type of disaster operation of the area (Firchau & Wiechert, 2005). However awareness through knowledge of spatial data is needed for disaster risk management among the decision makers. GIS is considered the most effective tool for visualization of disaster such as earthquake and can be responsible for life or death of the victims. It requires knowledge over relevant information that is present in the different administrations of the society. The analysis of the information should be comparable and consistent either in municipal administration or the country administration etc. Co-operation while collecting data and co-ordination among the different administrations of a certain scale and involved parties depending upon the need is essential. These involved parties such as the domain actors of disaster management community and the decision makers use the tools to carry out the activities by effective and efficient communication of the information (Groenlund, 2005).

## 1.5. Research Objectives

### 1.5.1. Main Objective

To analyse the present status of geo-information relevant for community resilience

### 1.5.2. Sub-Objectives

1. To perform an in-depth analysis of the current role of geo-information products and services, and related sharing practices and
2. To determine the gap between the desirable geo-information and currently available geo-information products and services and related sharing practices at each institutional level and the in earthquake disaster risk management phases and reflect on the roles of geo-information for community resilience

## 1.6. Research Questions

The questions derived from the sub-objectives are as follows:

Sub-Objective 1:

a) What are the issues of geo-information in Disaster Risk Management?
b) What are the products and services applicable in DRM?
c) Where is the status of geo-information in planning practices in DRM institutional structure specifically in earthquake disaster?

Sub-Objective 2:

a) How is geo-information accessed within the institutions in similar scenarios such as in the case of earthquake disaster in Haiti and Wenchuan?
b) What are the roles of geo-information in Community Resilience?
c) How are institutions lacking geo-information sharing practices in earthquake disaster risk management phases and where communities can help?

## 1.7. Research Framework

The conceptual framework identifies the elements that contribute to community resilience in a disaster. The elements are the stages of disaster risk management, phases of resilience and the flow of geo-information within the levels of institutions. Preparedness (mitigation), response, relief/recovery and rehabilitation/reconstruction are the elements included in DRM. Preparation, coping, recovery and adaptation are the elements for resilience. The elements of geo-information flow are within the social hierarchy of institutions such as organization (international, national and local), community, household and individuals. The elements are identified and organized in the conceptual framework to facilitate relation to define community resilience. It explains the community resilience by involving the resilience triangle.

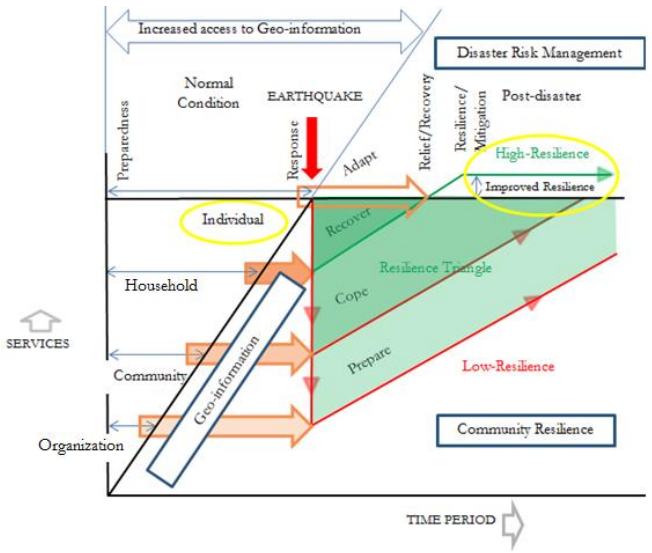
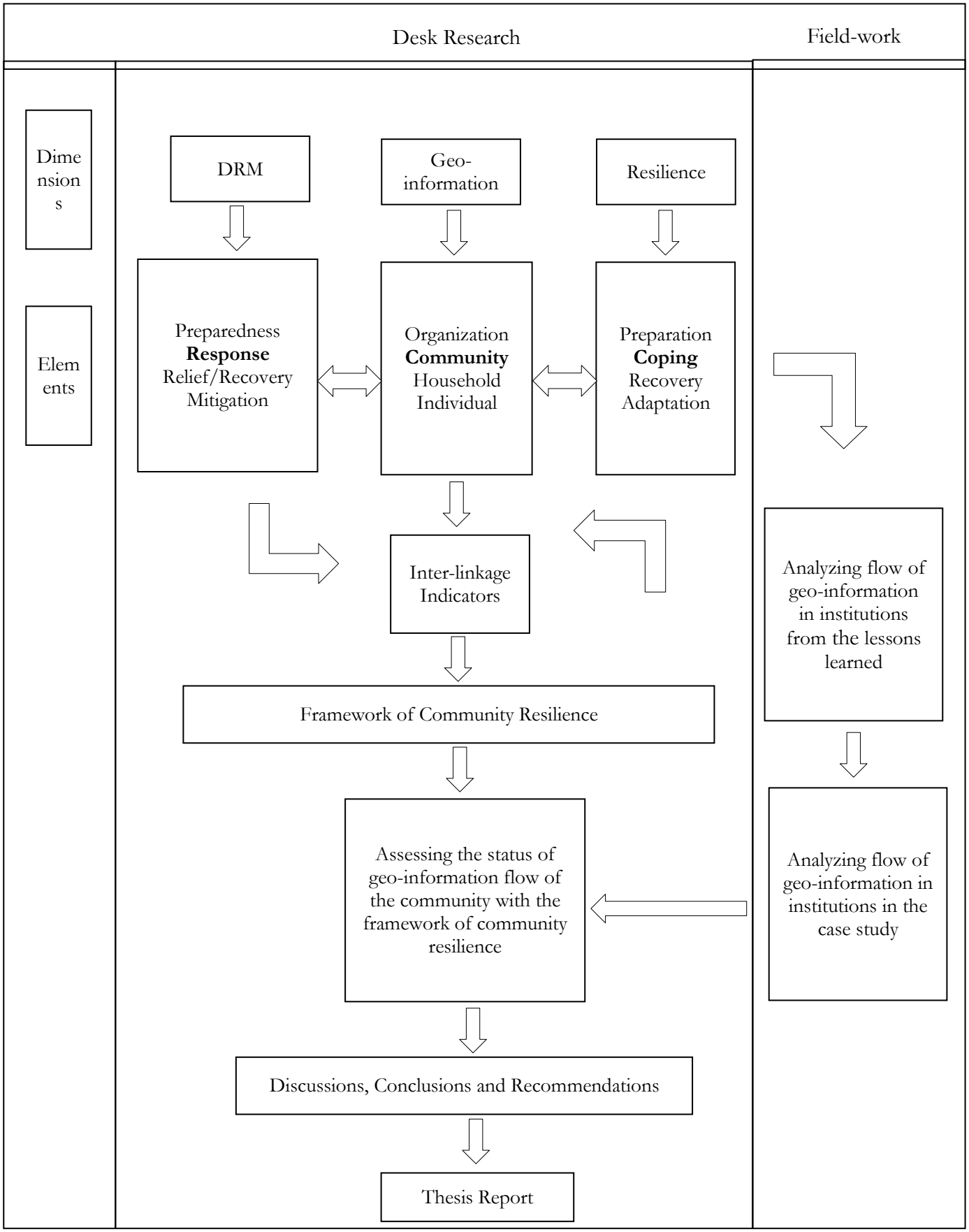



Figure 1 Framework of Community Resilience

It shows that resilience is there from the start throughout all stages of the framework. The flow of information in levels of institutions goes through all stages of DRM. It shows that the access of geo-information within the levels of institutions increases as their scale increases. They are cumulatively involved in all the four phases of resilience as well as the four stages of DRM. However in practice, there will exist gaps in the access of geo-information if one of their roles in the flow is missing. It will help to understand how a resilient community will come into play amongst the institutions in earthquake disaster.

### 1.8. Research Design

The research design refers to the literature review and the field-work study. They are as follows:



## 1.9. Study Area

Nepal is a seismically active country due to the presence of the fault lines occurred because of movement of Indian plate under the Eurasian plate. The earthquakes of 1834 and 1934 are recorded as the high magnitude earthquakes of the country amongst which 1934 earthquake damaged 60 per cent of the houses in Kathmandu, the capital city. The city that is highly populated is vulnerable due to the presence of poorly constructed buildings. However severe earthquakes do not occur every year but is predicted to cause a huge loss to the country in general and the community in particular.Therefore, the communities should be involved from preparedness stage as they are the ones who are at risk to face impacts ranging from worst to the inevitable (Pradhan, 2007). Lalitpur sub-metropolitan city, popularly known as Patan is located in about 5 kilometers southeast of Kathmandu in Bagmati zone. With its urban history dating back to as far as 2300 years, LSMC is one of the three major cities located inside the Kathmandu valley, besides Kathmandu and Bhaktapur (source: Lalitpur Profile). According to Central Bureau of Statistics of the Government of Nepal (2011), LSMC covers an area of 15.43 sq.km. with total population of 162,997, 35,000 households in 22 wards. The traditional communities in ward 12 having 1129 households is selected as case study area (Marahatta, 2011). The settlement is a core area of Patan having smaller communities attributed with physical, socio-cultural, and historical existence. A majority of the communities are from the caste system of newars. The buildings and infrastructures, both private and public are vulnerable to earthquake disaster mostly due to its ruined condition. The primary construction materials of the houses are permanent (e.g. concrete, stone, burnt bricks), semi-permanent and temporary (mud, unburnt bricks, wood etc). Therefore, the study takes into account the analysis of community resilience of selected area and discusses on improved community resilience.

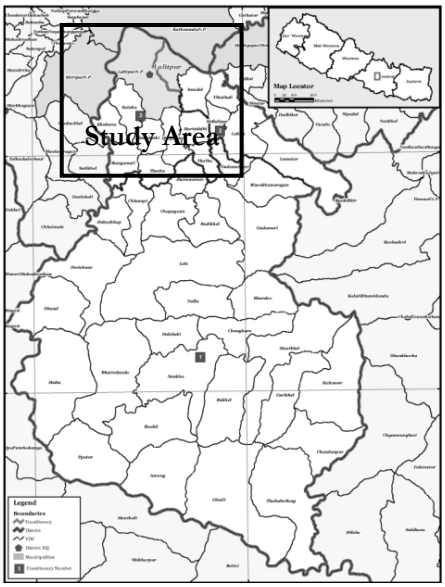



Figure 2 Case Study Area: Patan, Lalitpur, Nepal.source:http://www.un.org.np/maps/district-maps/central/Lalitpur.pdf)

## 1.10. Thesis Structure

The thesis has seven chapters. The contents of the chapters are as follows:

**Chapter 1: Introduction:** This chapter will give the overall idea of the research. It contains background, research problem, justification, research objectives, research questions, research design and thesis structure.

**Chapter 2: Literature Study:** This chapter is the literature review of disaster management, resilience and geo-information. It aims to have an overview to answer the research questions a) and b).

**Chapter 3: Framework of Community Resilience and Lessons learned in Earthquake Disaster:** The chapter identifies the elements and indicators of community resilience. This chapter is the overview of the status of geo-information in earthquake disasters in Haiti and Wenchuan. It also aims to answer research question c) and d).

**Chapter 4: Field Work Process:** The chapter gives an overview of the study area, Patan, Lalitpur, design and methods used for both primary and secondary data collection.

**Chapter 5: Analysis and Results of Community Resilience:** The chapter has the results of the analysis. Firstly it analyses flow of geo-information in institutions from the lessons learned. Then it analyses flow of geo-information in institutions in the case study. Then as a result, it assesses the status of geo-information flow of the community with the framework of community resilience. It also aims to answer research question e).

**Chapter 6: Discussions:** This chapter makes discussions on the ways in which geo-information can be made available in the institutions in earthquake disaster risk management phases. It discusses on how the national and local level institutions along with community based institutions can make improvements for community resilience. It also aims to answer research question f).

**Chapter 7: Conclusions and Recommendations:** The chapter draws conclusion and brings forward the findings, recommendations and further research.

# 2. LITERATURE STUDY

This chapter introduces the concepts of Disaster Risk Management, Resilience and Geo-information. It gives the literature to understand how the three concepts can come together and describe the contemporary scenario. The topic on geo-information is precisely dealt since it is the core of the research.

## 2.1. Disaster and Earthquake Disaster

Disaster is defined by the United Nations International Strategy for Disaster Risk Reduction (UN/ISDR, 2004) as 'A serious disruption of the functioning of a community or a society causing widespread human, material, economic or environmental losses which exceed the ability of the affected community or society to cope using its own resources.' In the last few decades, natural disasters have become more frequent and are more intense resulting to an increase in the number of victims (Manfré et al., 2012). Among others, high population growth, intense urbanization and disorderly occupation in the risk areas are responsible for the increased loss in disasters (Kobiyama et al., 2006). The increase in the frequency of disasters has made the communities across the world more vulnerable today and is further deteriorated by the critical infrastructures (Deshmukh & Hastak). Compared to other natural disasters there is difficulty predicting earthquake in advance and mapping the potential affected population. The reason is the nature of their abrupt occurrence affecting large areas and the unknown nature of their areas of vulnerability (Sorensen, Spada, Babeyko, Wiemer, & Grünthal, 2012).

Earthquake is one of the natural disasters among others such as floods and hurricanes that cause a widespread loss and suffering to the humans. Few recent examples are the earthquakes in Pakistan (2005), Indonesia (2006), China (2008) and Haiti (2010) and such events receive a greater part of media attention than the slow onset hazards which are geomorphologic hazards such as desertification, sea level rise etc (Van Westen, 2012). The earthquake of Haiti itself clarifies the fact that earthquakes cause the highest rate of destruction compared to 2004 tsunami in Indonesia damage which amounted to 2% of its annual economic output whereas that in Haiti amounted to 117% (Margesson & Taft-Morales, 2010, February).

### 2.1.1. Disaster Management and Disaster Risk Management

Disaster Management is the continuous and integrated process of planning and implementation of measures through multiple sectors and discipline. There is an interchangeable use of the terms such as disaster management, risk management, hazard management, crisis management and emergency management. Disaster Management is to manage the consequences of the events of hazard. The term risk management is to understand, manage and reduce risks practically through reduction of vulnerability relying on statistical data (S. Zlatanova & Fabbri, 2009). Therefore an important step for reducing risk is through information access and data sharing. The management and sharing of data brings the need to work with countries having them (Burzykowska, 2012).

There is an increase of the occurrence of natural disasters round the globe. The disasters cannot be avoided especially the one like earthquake but the risk can be minimized. This can be done through the execution of a properly planned disaster risk management program. Hence knowledge of disaster risk management is very necessary (Brooijmans, 2008). Extensive attention has been given in disaster literature about the linear nature of framework of disaster management. The steps or stages of this framework are planning, mitigation, preparedness, response, and recovery (K. J. Tierney, Lindell, & Perry, 2001). Disaster Risk Management involves management in the pre and post disaster phases through suitable applications. The efforts of planning, mitigation and preparedness are associated with the applications applied in pre-disaster whereas response and recovery efforts in post-disaster (Manfré et al., 2012). The pre-event actions are to lessen the damage. Mitigation presumes that the aspects of nature, society and its structure can be

strengthened to overcome the disaster. Preparedness in DRM should make effective delivery of resources in relief activities. The post-event actions such as relief and recovery anticipate shortening the time period to go back to the normal condition before an event. The thin line between the separation of relief and recovery is unclear, while earlier aims for tactics and the later for strategies (Gould, 2002). However, the different components of disaster management such as rescue, response, and recovery cannot be viewed in isolation (Twigg, 2007).

Disaster Risk Reduction (DRR) is a new concept broad in its context, and therefore it needs to be in consonance with the area of application which is socially equipped to minimize the risks and vulnerabilities as a result of disaster through application of policies, strategies and practices (Twigg, 2007). There is a shift of the pattern whereby preparedness driven approach is taking over the relief-driven approach. The local communities being both the main victims and respondents of natural hazards should be given a central position while executing the plans of Disaster Management (DM) (Pradhan, 2007). In developing countries, the earthquake loss estimation proposes for an urgency to support local authorities.

There is a vital need of collaborative methods of information collection and management for strategy implementation towards disaster preparedness. This can be carried out by having hierarchy in data collection of municipality staffs, local institutions and local communities (van Westen, Piya, & Guragain, 2005). It is because the level of planning for preparedness of the agencies who respond and the available capacities and resources at levels determine the effective humanitarian response during crisis (Nepal, 2011). There is a need of constant adjustments in decision making and interaction at the various interlinked levels having institutions behaving as actors namely, organizations (government and non-government), individuals, households and communities in the dynamic process of Disaster Risk Management (Pantoja, 2002). It justifies that these institutions are at equal stake for involvement in all the components of the stages of DRM.

### 2.1.2. Disaster Management Cycle

There are four phases of Disaster Management accepted in agencies all over the world are prevention and mitigation, preparation, response and recovery. However, there exist institutions which work under their own national specifications.
In spite being equally important, they also have their specific characteristics (S. Zlatanova & Fabbri, 2009).

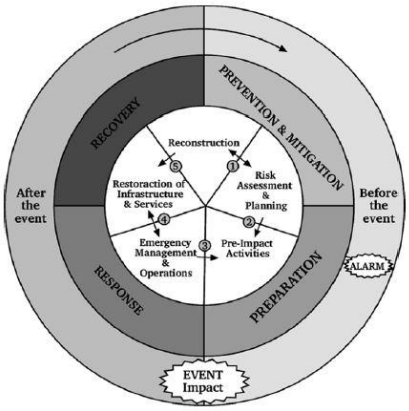


Figure 3 The disaster management cycle (source: PSC Forum, www.publicsafetycommunication.eu)

The focus of Prevention and Mitigation is towards reducing vulnerabilities of hazards by applying long term measures (S. Zlatanova & Fabbri, 2009). The activities that facilitate preparation during the act of responding to an occurring disaster refers to Preparedness or Preparation phase (Manfré et al., 2012). Active preparations for a possible emergency situation through trained rescue services e.g. police, ambulance and fire brigade to operate and cooperate is the focus of Preparation. The challenging, dynamic and unpredictable situation after the occurrence of an emergency (S. Zlatanova & Fabbri, 2009) involving immediate and short-term effects (A.; Mansourian, A.; Rajabifard, & M.J. Valadan Zoej, 14–16 October 2005) is the response stage. Recovery covers the stage where various arrangements on damage removal and long term supply of resources to the losses occur (S. Zlatanova & Fabbri, 2009) towards activities that restore the community to pre-disaster conditions through restoration activities etc (A.; Mansourian et al., 14–16 October 2005).
Such stages and their activities depend upon up-to-date integrated field information accessed through reliable agencies having fast response to assist decision makers to disseminate them among the rescue teams, citizens etc (S. Zlatanova & Fabbri, 2009). The measures are intended to prevent and reduce disaster risk, mitigate their severe consequences, to prepare for emergency, for rapid and effective disaster response and post-disaster recovery and rehabilitation. This process requires the significant and strong

capacity to track, collate, monitor and disseminate information related to the activities and their specific phenomenon (President, 2003).

Van Westen (2012) brings the more positive concept of 'risk management cycle', or 'spiral' which focuses on adaptation and modification than simply working on reconstruction of the conditions prevailing in the physical and social aspects. The author illustrates the disaster cycle and its various components as discussed by UN/ISDR such as relief, recovery, reconstruction, prevention and preparedness by analysing its change through time. Initially, disaster relief, recovery and reconstruction are given more attention, and then the attention shifts to disaster preparedness initiated by having warning systems and awareness programs. The figure shows that the aim of disaster risk management is to form larger cycle compared to the earlier one with a smaller one.

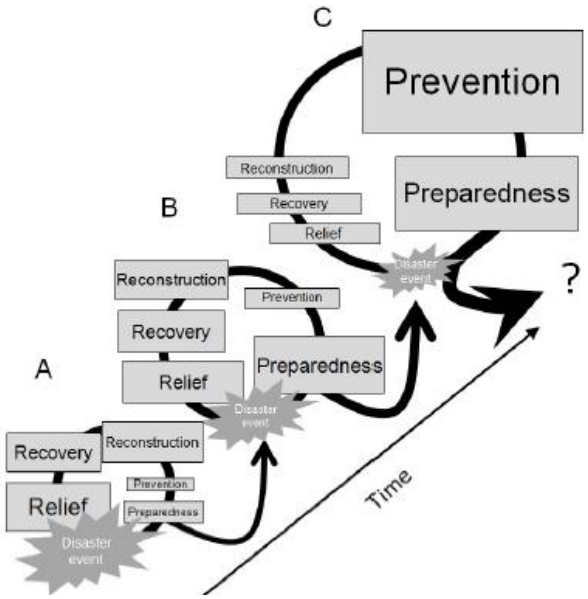



Figure 4 Disaster Cycle and its development through time (Iglesias, 2005)

According to Piper (2011), there are three main stages of Disaster Risk Management Cycle (DRMC), namely Normal/ Risk Reduction Stage, Emergency Stage and Recovery Stage. DRMC can be applied in a quick onset disaster such as earthquake having a sequence of activities in its three stages. The following figure 8 shows its inter-linkage:

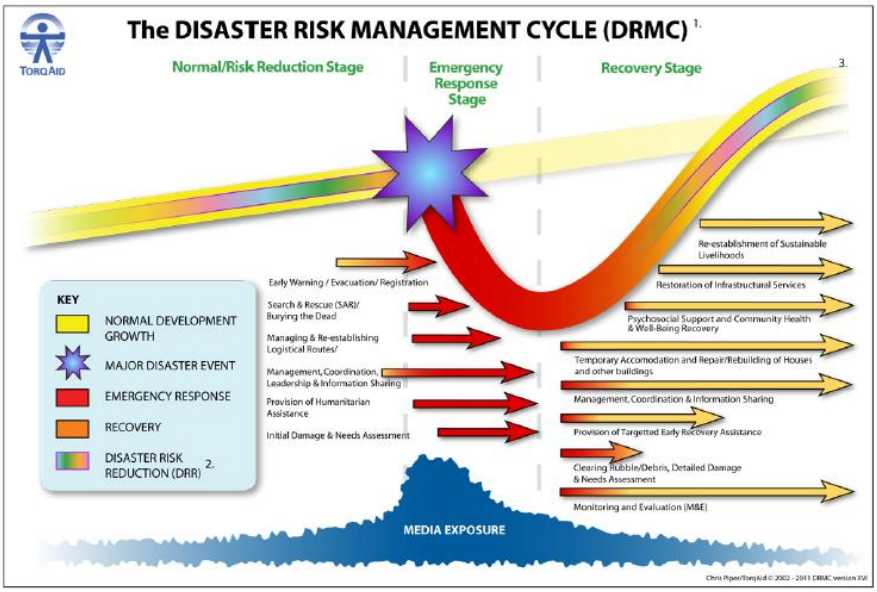



Figure 5 The Disaster Risk Management Cycle (DRMC)

Emergency Response Stage is sudden during the Normal Development Growth and that which may only continue for few days or weeks whereas the Recovery Stage lasts for a longer

time. The following parameters occur in the Emergency Response Stage, namely:
"The Early Warning/Evacuation/Registration

- Search & Rescue (SAR)/Burying the Dead
- Managing and Re-establishing Logistical Routes
- Management, Coordination, Leadership and information Sharing
- Provision of Humanitarian Assistance
- Initial Damage & Needs Assessment

Similarly, during the Response Stage, the following parameters occur, namely:

- Management, Coordination and information Sharing
- Clearing of Rubble/Debris. Detailed Damage & Needs Assessment
- Provision of Targeted Early Recovery Assistance
- Temporary Accommodation and Repair/Rebuilding of Houses and other Buildings
- Psychosocial Support and Community Health & Well-Being Recovery
- Restoration of Infrastructural Services
- Re-establishment of Sustainable Livelihoods
- Disaster Risk Reduction (DRR) Initiatives
- Monitoring & Evaluation (M&E) (Piper, 2011)

### 2.1.3. Hyogo Framework for Action

Our communities are least resilient to natural disasters. The authors in the past decade have highlighted to research on the concept of resilience in the field of disaster reduction (Mayunga, 2007). The concept of disaster resilience has gained quite a lot of interest due to the adoption of Hyogo Framework for Action 2005-2015: Building the resilience of nations and communities to disaster (S. B. Manyena, 2006). The literatures on disasters show that there is less of assessment of hazards and more of analysis of vulnerability and building community resilience (Ainuddin & Routray, 2012). It focuses on building community resilience which contrasts to only reducing vulnerability, shifting the paradigm to resilience based approach from vulnerability assessment approach (Mayunga, 2007). It has been acknowledged as a global road map for disaster risk reduction and needs to be considered very frequently during disaster risk reduction initiatives.

The Hyogo Framework for Action 2005-2015, under the United Nations, International Strategy for Disaster Reduction (ISDR) is allied in building the resilience of nations and communities to disaster which is illustrated in Annex 1. It consists of an expected outcome, strategic goals and priorities for action for the ten years of period. The expected outcome would be to have a substantial reduction in losses of lives, social, economic and environmental assets in communities and countries that are affected by disaster. Amongst the strategic goals, the research emphasis is towards the development and strengthening of institutions, mechanism and capacities to build resilience to hazards. According to the ISDR, the priorities for action in this strategic goal is to use knowledge, innovation and education to build a culture of safety and resilience at all levels (Framework, 2005). This includes key activities which are as follows:

- Information sharing and cooperation;
- Networks across disciplines and regions; dialogue;
- Use of standard DRR terminology;
- Inclusion of DRR into school curricula, formal and informal education;
- Training and learning on DRR: community level, local authorities, targeted sectors; equal access;
- Research capacity: multi-risk; socioeconomic; application;
- Public awareness and media.

## 2.2. Resilience

According to Multidisciplinary Center for Earthquake Engineering Research (MCEER), resilience is the inherited strength, flexibility and the adaptability seen even after a stressful event. The inherited strength

helps to function during normal days whereas the ability to adapt refers to its flexibility during and after the stress. Having inherited strength can result in better adaptive qualities maybe a correlation among them (K. Tierney & Michel, 2007). Van Westen (2012) defines resilience as: "The ability of a system, community or society exposed to hazards to resist, absorb, accommodate to and recover from the effects of a hazard in a timely and efficient manner, including through the preservation and restoration of its essential basic structures and functions." Sudmeier-Rieux (2014) accepts that resilience has taken a firm hold in development, humanitarian, DRR discourses, a pragmatic approach can consider resilience as: the ability of a system, organization, community, household or individual to change in a positive manner, when faced with adversity. It is broadly stated by ISDR as the capacity of a system, community or society potentially exposed to hazards to adapt, by resisting or changing in order to reach and maintain an acceptable level of functioning and structure (Framework, 2005).

The indicators of the community defining their existing capacities can be used to measure resilience. However, source of national data is outdated and the local impacts affecting communities are not well addressed. In addition, local data are also not comparable and therefore are of little use (Cutter, Burton, & Emrich, 2010). The vulnerability of the organization also quantifies resilience. Resilience of a system depends upon the organization's adaptive capacity by two ways. They are either by having them redundant or by having a speedy progress to an entirely new situation (Dalziell & McManus, 2004).

### 2.2.1. Resilience Triangle

Resiliece is represented by the resilience triangle. The basic principle of the resilience triangle is that the smaller the triangle, the higher the resilience. Higher resilience requires minimal damage in critical lifeline services after a disaster, speedy recovery of those services, and an overall improved service level as a result of rebuilding damaged systems and implementing better systems. As shown n figure 2 resilience triangle illustrates that high resilience is due to a combination oflow losses, quick recovery and services improved to a higher level than before the disaster. The resilience diagram indicates that Chile and Japan have high levels of earthquake resilience. At current stage, Oregon's infrastructure has low resilience and is expected to have significant loss of sector services and a slow recovery time (Wang, Bartlett, & Miles, 2012).

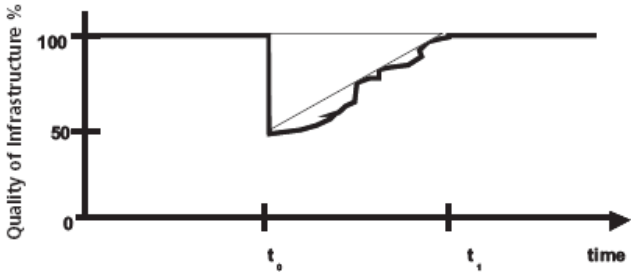


Figure 6 The Resilience Triangle

The measurement of resilience can be done by the level in which an infrastructure system can function with respect to the time taken for the system to bounce back to a performance level that existed before the disaster event. The resilience triangle as in Figure 3, signifies the damage driven loss of the function and the pattern of recovery with respect to time. It illustrates that the resilience can be enhanced by reducing the size of resilience triangle by applying strategies that enhance function of the performance of infrastructure and decrease the time to recover. Both the performance of infrastructure and time of recovery can be improved by mitigation measures through restoration and replacement of the infrastructures. Regarding this the phases of resilience such as preparation, coping, recovery and adaptation take a central stage.

### 2.2.2. Disaster Resilience

According to (MCEER), disaster resilience is the outcome of social entities such as organizations and communities, their ability towards hazard mitigation, overcoming disaster, minimizing social stress through recovery activities along with future disaster mitigation. The literature of MCEER reveals that resilience from cross-disciplinary studies view it as inherent strength and the capacity to be flexible and adaptable after stress related to destruction. Initially, this concept was visible in disaster related literatures in the 1990s. The prominence of resilience has gained its grip after the catastrophic event of hurricane Katrina in August 2005 having replaced the concept of disaster resistance. The earlier concept of disaster

resistance was engrossed in measures of mitigation to have better performance in structures, infrastructures and institutions. In the other hand, resilience is occupied to build the capacity of physical and human systems to respond and recover in disaster.

Disaster Risk Management is carried out basically to render a resilient community so that it may come back to its original form of even a step higher following a disaster. So the resilience is very much linked to disaster risk management which is carried out by addressing its cycle. Resilience is determined by the degree to which the social system is capable of organizing itself to increase its capacity for learning from past disasters for better future protection and to improve risk reduction measures (UN/ISDR, 2007). The concept of resilience motivates the capacity of the people to respond to disasters (J.-C. Gaillard, 2007). The cross-cutting issue in this case is community and volunteers participation (Framework, 2005). However, it remains an object of discussion within the social scientists in its concept and application.

Resilience is an all-encompassing metaphor and a buzzword in multi-disciplines including disaster for managing risk. Then national and international governments and organizations prioritize to attain high resilience levels in their DRR agendas. However, the definition and methodologies regarding resilience in communities facing disasters is not yet defined (E.Verrucci, 2012). The clarity in assessment, measurement and mapping of disaster resilience is yet not present. The challenge lies in developing indicators that can measure the concept. The absence of a conceptual framework that defines and measures the indicators is a drawback for forming strategies and policies for disaster reduction (Mayunga, 2007). He develops a conceptual framework that can assess and map community disaster resilience.

### 2.2.3. Phases of Resilience (Prepare, Cope, Recover and Adapt)

Resilience to disasters focus on the measures of mitigation in order to reduce losses by enhancing the affected structures, infrastructures and institutions. It is the capacity to respond and recover by improving the physical and human resources (K. Tierney & Michel, 2007). Coping with earthquakes of a moderate one does not indicate preparedness of a great one (NRC, 2011).

The attributes of resilience is the capability for self-organization, learning and adaptation (Carpenter & Gunderson, 2001). From ecological perspective on natural disturbance of ecosystems, resilience is the system's ability to adapt or to preserve its equilibrium condition as per the pre-disturbance state or its adaptive capacity to transform to a different state as a result of stress (Folke, 2006; Holling, 1973). In case of crossing the critical thresholds, the system can reach to a either state termed as 'transformability', which can be better, or worse (Alliance, 2007) (Alliance, 2007). Haimes (2009) focus on the system's ability to recover following a shock in certain period of time. In the time of shock, resilience also equals to the capacity to cope and the strategy laid to recover when defined as the more narrow sense of 'returning to a normal state' as a concept that describes more efficient recovery after crisis (Sudmeier-Rieux, 2014). Burton, Roberts, Montaldi, Novick, and P. (1993) assumes that adaptation and coping strategies is dependent upon the nature of threat and the time period to lessen the risk where the process of making adjustments in the systems for adaptation is longer compared to that of coping.

Resilience was pioneered from climate change perspective as 'elasticity' or 'the measure of a system's or part of a system's capacity to absorb and recover from the occurrence of a hazardous event (Timmerman, 1981). Thus community resilience strengthened the prevention, preparedness and response to disasters by supporting the guidelines for the local government (Buckle, Marsh, & Smale, 2003; S. L. Cutter et al., 2008; Paton & Johnston, 2001). Resilience is the characteristics of the system that absorbs, copes and adapts the impact of stress event and post-event process enabling it to respond to the event in such a way that it can recognize, change and learn from the consequences (Susan L. Cutter et al., 2008).

Disaster Resilience is one of the major challenges of present which is addressed by major activities such as preparing, responding and adapting. The theme of preparing is for reducing the potential physical damage by adapting to our changing world. It includes coping under having emergency response strategies. Similarly, responding as a theme would be towards improvement when disasters do strike. Finally,

adaptation addresses to the psychological impact of disasters on areas of disaster and to those as a system who are directly or indirectly involved to respond to such disasters.

### 2.2.4. Social Resilience

Among the four resilience domains technical, organizational, social, and economic (TOSE) identified by MCEER, social resilience refers to the characteristics of the community referring to their ability to adapt to disasters and lessen their negative consequences on the community and its governmental rules. The indicators include poverty level, education level, linguistic ability, access to resources such as evacuation (K. Tierney & Michel, 2007) etc.

Disaster resilience emerges the social resilience into the scene because the people who are affected by disasters are deeply entrenched in the society (Kimhi & Shamai, 2004). There is an increase in acceptance of the link between social capital and disaster resilience. Social ties in the immediate aftermath of disaster serve as informal insurance or mutual assistance involving friends and neighbours. They provide financial as well as physical assistance and information, tools, resources such as space etc (Meier, 2012).

Daniel Aldrich states that "social resources, at least as much as material ones, prove to be the foundation for resilience and recovery (Aldrich, 2012)." The role of friends and family, co-workers or the passerby should be recognized on the front line of disasters as they are always the first to respond. They are most effective compared to the government agencies, private firms, NGOs who are affected and lack systematic assistance since the neighbours and community groups are best at undertaking the initial steps after a disaster (Aldrich, 2012).

A change has taken place in the lifestyle of the traditional societies to recover from damage of disaster. Such modifications may be slight, large or incremental and changes maybe temporary or long lasting. This is however seen as a mode of coping and recovery (J.-C. Gaillard, 2007). The response capacity also depends upon the resilience capacity of the people during disasters (Klein, Nicholls, & Thomalla, 2003). This is where the term resilience comes up in the society. Recently, the policy debates have community resilience building as the central concepts (Kafle, 2012). It is because of the potential of resilience to comprehend and systematize risk reduction approaches and guide the decision-makers (Sudmeier, Jaboyedoff, & Jaquet, 2013). Yet the approach varies with the level of awareness and strategies while its measure is specifically determined by its location and type of disaster (Kafle, 2012).

The factors have to be identified as a methodology to make a prediction for an enhanced level of resilience by making a comparison of the communities which have responded differently to the disaster event. The following literature reviews bring the following factors of relevance with a certain degree of overlap (Maguire & Hagen, 2007):
Trust (Enemark, 2006)
• Leadership (Ink, 2006)
• Collective efficacy (Moore et al., 2004)
• Social capital (Breton, 2001)
• Social cohesion and sense of community (Poynting, 2006)
• Community involvement (Clauss-Ehlers & Levi, 2002)
• Existing norms/attitudes/values (Oxfam, 2005)
• Communication and information (Ink, 2006; Rohrmann, 2000)
• Resource dependency (Adger, 2000)

**Resistance, Recovery, Creativity**

There are three properties of social resilience: resistance, recovery and creativity involving the aspects on how people respond to disasters (Kimhi & Shamai, 2004). Each of these properties is established by the high resilient community. Resistance is the property of resilience in a community that helps to resist the consequences of the disaster. In such a case, the community is not expected to undergo a long-term

change but having gone through a certain degree of disruption, preferably to its social structure (Adger, 2000). The figure shows that resistance is the distance between the community's pre-disaster level (r') and threshold (t) outside which it will be impossible for the community to return back to its earlier state. The

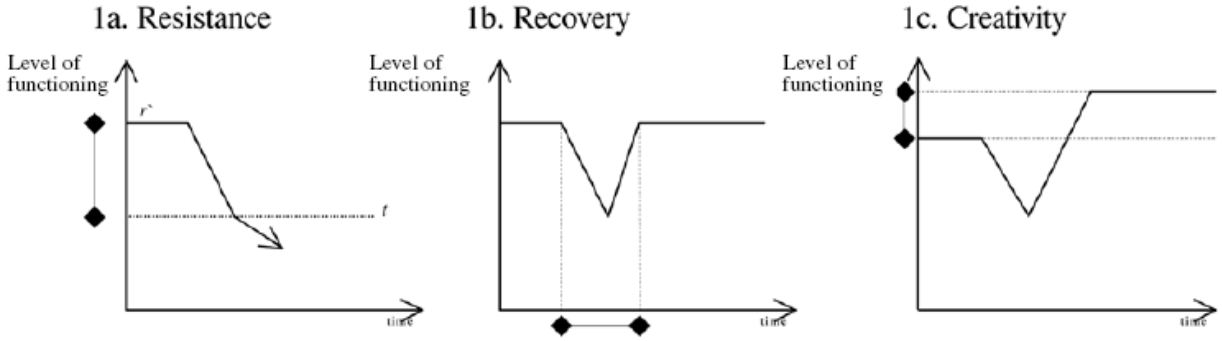



Figure 7 Properties of resilience (Adger, 2000)

further the distance between the two, the better the level of functionality and the higher the resilience (Maguire & Hagan, 2007).

Similarly, recovery is the ability of the community to pull through the stress of disaster (Adger, 2000; Kimhi & Shamai, 2004). It relates to the idea of community to bounce back to its pre-disaster state (Breton, 2001). It is also related to the time taken by the community to come back to its earlier state of functioning where the analysis is that a more resilient community returns to pre-disaster state efficiently and inefficiently, sometimes having slow recovery or even sometimes tend to fail to recover as compared to a less resilient community (Aguirre, 2006). However, an optimal recovery is explained as not having the goal to reach the pre-disaster state or an initial equilibrium point but to reach to a higher level of functioning of better resilience by learning from the experiences of disaster and adapting to new settings (Kimhi & Shamai, 2004; Pooley, Cohen, & O'Connor, 2006; Sonn & Fisher, 1998). This is however the property of creativity which continues from the property of recovery leading to a gain in resilience (Kimhi & Shamai, 2004). Therefore a creative community teaches the individuals on how to act or recognize the signs of stress by having lessons learned from disaster events in the past to attain a higher level of resilience (Maguire & Hagan, 2007). "In an ongoing process, a resilient community predicts and anticipates disasters; absorbs, responds and recovers from the shock; and improvises and innovates in response to disasters (Maguire & Hagan, 2007)."

#### 2.2.4.1. Organizational (social) Network

The physical components are managed by the organizations involved in the system. The domain of organizational resilience contains among others, information management as a measure that defines organizational capacity by managing critical facilities and decision making to improve disasters. The physical components are emergency operations centres, communications technology, and emergency vehicles. Similarly the organizational components of the emergency management are the disaster plans, lessons learned from past earthquakes, training and experience of personnel involved etc (K. Tierney & Michel, 2007).

There is a great importance of co-operation and co-ordination. Co-operation is in collecting data whereas co-ordination in the wants and needs of the different administrations in the municipality (Grönlund, 2005). There should be collaboration and exchange of information between different partners in various levels of administrations. Such are the prior development of dedicated centers having command and control systems or either temporary management centers or ad hoc centers should be created post-disaster. In such cases, dynamic data collection and management should be done by an appropriate organization (S. Zlatanova & Fabbri, 2009). These are also donated by the private companies and institutions in some

circumstances (H. Brecht, 2006). Both the policy makers and the public should have access to the correct data and information for making good decisions to build resilient societies (GFDRR, 2014).

Social networks according to researchers are thought of as the mediators that flow the information within the communities and the organizations (Walker, Kogut, & Shan, 1997). The social network analysis approach is a technique that studies the exchange of resources in the form of information among the actor such as individuals, groups or organizations. Social networks are formed as a result of regular pattern of exchange of information, actors in the form of nodes and information if the form of connecters of the nodes analyzing in terms of exposure to and control of information. Such analysis helps to be aware of the status of the information exchange in the connectors where the actors proving information choose the best opportunity and make modifications for an improved information service delivery (Haythornthwaite, 1996). The analysis emphasizes on the relationship patterns and examines the availability of resources between the (Scott, 1991)actors (Scott & Carrington, 2011). These resources are either tangible such as goods, services, money while also intangible such as information, social support, influence (Haythornthwaite, 1996). For e.g. The Ordinance Survey, Great Britain which was initially national mapping agency has become the provider of geographic information having the possibility of integrating, exchanging and understanding related information through the development of geographic framework (Parker & Stileman, 2005).

### 2.2.5. Community Resilience

Building the resilience of our communities is the ultimate goal of the efforts made by disaster risk reduction. The communities, government actors and different sectors at all levels from local to national should be responsible and share a common understanding of managing and mitigating risks for resiliency. There is a gap between the scientists, policy makers and the communities which needs to be bridged in the sector of disaster risk reduction. There are technologies but the ownership among the communities is essential to take subsequent action. There is an advantage of open data and open source software and encouragement in participatory mapping for using science to guide the action of the communities and levels of government and advocate for disaster risk reduction. The full value of the actionable scientific efforts through better knowledge, understanding and belief in communities and government is the necessity for a resilient community (Dhu, 2011).

#### 2.2.5.1. Community Resilience in Disaster Risk Management

Timmerman (1981) who related the concept of resilience with hazard and disaster for the first time defined it as the capacity of a system or a part of a system to recover from events of disaster. There is no common definition of resilience on disaster fields because of the fact that there are different degrees of resilience in among groups, communities or individuals that which is variable with time (McEntire, Fuller, & Weber, 2002). Among many definitions by authors, the one with the notion of adaptation is a process oriented with respect to a system having implications to policies (S. B. Manyena, 2006). The social system can organize again and maintain the process and structure, having capacity for learning and coping within the process of adaptation (Mayunga, 2007).

World Disaster Report 2013, shows that people's ability to prepare, cope and recover from disasters is highly dependent upon access to information and technology, particularly mobile phone and texting. These new technologies enhance the community affected by disasters to be able to help themselves. In the critical coping hours of earthquakes, the local people are responsible to save lives. However, these first responders do not have access to information and tools ranging from early warning systems, basic connectivity and infrastructure network. The humanitarian organizations, government, private sector and local communities should work together for access to information to the disaster affected communities. Along with technologies, digital operations centre are set up where posts of social media are tracked from the disasters affected areas and made applicable through integration in response decision making (IFRC, 2013).

Disaster Management aims to get the community to the stage of pre-disaster by getting involved in lessening the disaster effects towards the community (Brooijmans, 2008). According to Geis (2000), a safe community can itself design a contextual setting through its knowledge towards disasters by applying measure of DRR to enhance its capacities. Capacity building along with enhancing infrastructure performance can increase community resilience during recovery phase of disaster. They include loss assessment tools and locally available data of available and required capacities including both the social and economic activities. The recovery will be within a certain time frame when infrastructures provide service and sustain social and economic activities and when capacity mitigates losses (Deshmukh & Hastak).

The cycle of DRM is studied in order to achieve a certain level of resilience among the community in case of earthquake disaster. The risk can be minimized by having community participation in the stages of DRMC. An improved resilience is the outcome of improved stages in the cycle, the ability to prepare, respond, recover soon through enhanced mitigation activities, supported by up-to-date risk assessments. There is a wide range of implication on the community because they are locally bound in certain context and the severity of disasters is dependent upon the level of their resilience. DRR has a role to play by carrying out strategies such as UN/ISDR practiced in countries around the world.

Considerable work has been done for the development of models and framework for community resilience assessment. However no common framework is present for measuring or monitoring community resilience to disasters (Birkmann, 2007; Zhou et al., 2010). An example of a model for assessing community resilience is developed by (Susan Cutter et al, 2008) is the Disaster Resilience of a Place Model (DROP). Apart from this theoretical framework and indicators, the author also provided a number of indicators which are tested at the national level (Ainuddin & Routray, 2012).

#### 2.2.5.2. Disaster Resilient Community

Disasters and failures in the critical infrastructure escalate the impact and make communities less disaster resilient (Leavitt & Kiefer, 2006). The ability to cope through strength and flexibility and overcome the challenges as a result of extreme disaster events are the trademarks of a disaster resilient community (MCEER).

Mayunga (2007) refers the concept of community disaster resilience as the community's capability to anticipate, to prepare, to respond and to have a quick recovery after the stress of disaster. Hence it does not depend only on how a community recovers but also in addition depends upon the learning, coping or adapting ability. Community resilience is determined by minimal disaster effects and quick recovery period. Figure 11 represents the hypothetical trajectory of two communities as follows:
(1) a more resilient community (solid line), and
(2) a less resilient community (dotted line).
The hypothetical trajectories shows the change in the status of the communities through the time period of four phases such as pre-disaster, disaster, restoration and long term recovery. It shows that greater impacts and fluctuation occur in the less resilient communities compared to the resilient communities. It concludes defining the property of a less resilient community as the one that take longer time period to recover and come back to normal condition.

There has been a formation of nine minimum characteristics for disaster resilient community in Nepal. It is the result of several workshops of Flagship 4 in 2010 and 2011 by consultation with government, INGOs, NGOs, UN, donors and consultation in Nepal Red Cross/Red Crescent movement (MoFALD, 2013).

They have formed baseline components for a disaster resilient community in Nepal. The following illustrates these nine characteristics and the figure is at the Annex 2:

1. Organizational base at Village Development Committee (VDC)/ ward and community level
2. Access to Disaster Risk Reduction (DRR) information
3. Multi-hazard risk and capacity assessments
4. Community preparedness/ response teams
5. Disaster Risk Reduction/ management plan at Village Development Committee (VDC). Municipality level
6. Disaster Risk Reduction (DRR) Funds
7. Access to community managed Disaster Risk Reduction (DRR) resources
8. Local level risk/ vulnerability reduction measures
9. Community based early warning systems

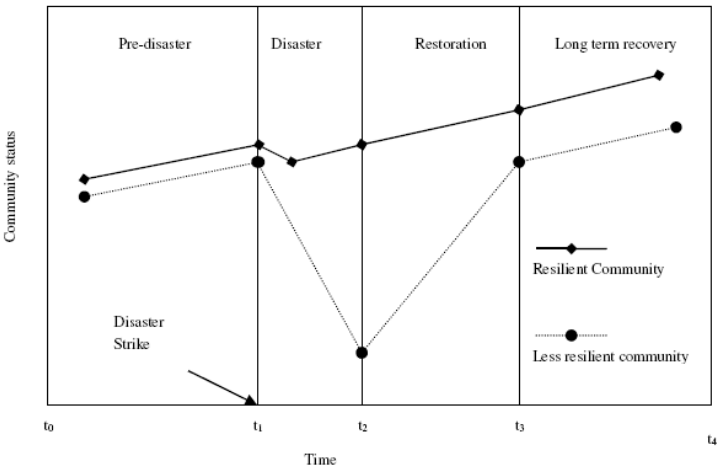



Figure 8 A hypothetical trajectory of resilient and less resilient community (Modified from Zhang)

However this is designed for the rural context but the urban context disaster resilient community can also use the characteristics as an added value. This can be tested in the community level by applying these characteristics to see if it promotes the development in disaster resilience. Furthermore, the characteristics outline can be reframed for context specific assessment by adding the missing indicators in the particular urban setting (MoFALD, 2013). These can be done by developing specific outcome and impact indicators that bring the efforts of the community level activities in disaster resilience. The figure in Annex 3 shows the minimum characteristics of development process.

## 2.3. Geo-information

Geographic data refers to the geospatial technologies such as remote-sensing (RS), Geographic Information System (GIS) and Global Navigation Satellite System (GNSS). Such techniques need the availability of data and information and government staffs who can technically handle and analyze such information. Such information is shared in the form of spatial data by establishing Spatial Data Infrastructures (SDIs) in the context of disasters. However, an improved prevention and emergency plans require the participation of organizations and government for the information exchange. In addition, from the grassroots level, the citizens are involved through voluntary data collection by using the application volunteered geographic information (VGI). Similarly technical institutes and research groups such as the Platform for Space-Based Information for Disaster Management and Response (SPIDER) is established by United Nations (UN). It is involved in ensuring the accessibility and capability among the organization and countries to support the risk and disaster management in their entire cycle through programs in order to minimize the negative effects of disasters (Maccann & Cordi, 2011).

The International Charter is an international agreement among the Space agencies to provide with information and data for the response and relief efforts of emergency situation caused by disasters. The information needs for the crisis mapping are reference maps such as place names, human and economical assets and infrastructures within 6 hours as well as fast damage maps including destroyed areas within 24 hours of the disaster taking place. The 40 Charter member countries from their national Disaster Management Authorities can obtain the information in the time of emergency along with other countries that cooperate for disaster relief. Similarly the UN agencies activate the Charter (Bally, 2012).

The geographic core data such as topographic maps, aerial photos etc is expected to be accessed directly online at the supplier's core database in open interface standards of ISO/OGC (Open Geospatial Consortium). Location based services (LBS) such as mobile phones; PDAs, tablet, laptops etc are used with GPS location to locate as a productive form of information. In addition, geographical web services have online access to geographic databases distributed by plotting information on the map through web for increases flow of information in crisis situations. However there are risks in geo web services of reliability and availability of infrastructures of communication through internet and mobile. So, the biggest challenge lies in the geo-information community in setting up of data/information infrastructure of disaster management Location technology such as geo-information, geo services, communication infrastructure (wireless) is crucial for successful location based services, which is the result of considerable community efforts. The parties involved should have rights and obligation clarity. In addition, decision makers are supplied with raw geographic information such as maps of hazard zones, landuse etc and the data is not integrated resulting to late visibility of information implications and formulation of inadequate decisions and policies (Grothe, Landa, & Steenbruggen, 2005). The foremost priority goes to the political deals to obtain high quality geospatial technology application in disaster risk management (Manfré et al., 2012). Global Disaster Alert and Coordination System (GDACS) under United Nations are established in 2004 to consolidate and strengthen worldwide disaster information related provider and user groups. It assists in providing reliable and accurate disaster alerts and their impact assessments for improving cooperation from international responders and has developed for critical disaster information systems through web based service. GDACS consists of web-based automatic alert notifications and impact estimates, emergency managers and operation center community as well as automatic information exchange between other web-based information systems for disasters such as JRC, Virtual OSOCC, ReliefWeb and UNOSAT (De Groeve, Vernaccini, & Annunziato, 2006).

The increased occurrence of natural disasters is primarily the result of social factors and in addition geological and weather phenomenon that require satellite images for disaster management. Vulnerability analysis of a region of interest is potentially achieved making use of remote-sensing data and GIS techniques. However, the techniques should be adapted according to the area to be analyzed (Manfré et al., 2012). Geo-information procedures is not constant as it is a part of mainstream information ranging from spatial databases, wireless, GPS, mobiles, computers etc which are ever changing (Parker & Stileman, 2005).

### 2.3.1. Earth Observation

"Earth Observation plays a central role in various aspects of disaster management such as Monitoring, Hazard Analysis, Vulnerability- and Damage Assessment, Contingency Planning, Reporting Systems as well as Early Warning Systems. Near real time satellite derived information is critical to decision-making and provision of disaster relief. Provision of immediate disaster relief can be enhanced through the provision of accurate satellite derived maps that can be used for assessment of the situation to enable logistical support (Mangara, 2012)." Satellite images are provided for free by the international arrangements in the regions affected during natural disasters. International Charter for Space and Major Disasters is the international agreement that collaborates among the space agencies to address the phases of pre and post disaster. Among many, the Indian charter member is the Indian Space Research Organization (ISRO), the US is the United States Geological Survey (USGS) and the for Japan is the Japan Aerospace Exploration Agency (JAXA) (Charter, 2013).

There are instances where the United Nations conducts initiative in countries through the United Nations Space-based Information for Disaster Management in Emergency Response (UN-SPIDER). They use satellite technologies especially the orbital remote-sensing images to develop prevention and mitigation methodologies and are supported by their specific governments and universities (Manfré et al., 2012). Both airborne or space borne, traditional systems of remote sensing (RS) in short response time can generate very high resolution data. However, the geographic information with adequate spatial resolution are not received by the decision makers. Therefore the absence of real database of high spatial resolution

images like IKONOS or Quickbird cannot give estimate precisely of the damages consequently after disasters such as earthquakes (Lewyckyj & Everaerts, 2005b).

### 2.3.2. Spatial Data

Brooijmans (2008) explains how to measure the added value of geo information in disaster management and that geo-information has provisions for all aspects of disaster management cycle. Spatial data is significant in disaster management since the most important information in this field is a spatial element (Mansourian, Rajabifard, Valadan, & Williamson, 2006; NRC, 2011). Geographical footprint along with temporal information gives the impact and duration of a disaster and the geospatial data and tools such as imagery, maps and data sets etc link the events to a place on earth. These tools are used in the four phases of disaster management, such as in mitigation for long term planning and forecasting, analytical modelling is done by the use of GIS or geographic information. Similarly, in preparation and response phases, geographical queries are carried out and this requires a timely and accurate answer for having an ultimate decision making through information integration and dissemination. The ultimate need in disaster management is to have meaningful information which is the information of value in the process of decision making (Brooijmans, 2008).

An effective disaster management collaborative decision-making requires the spatial data and the technologies associated with it (A. Mansourian, A. Rajabifard, & M.J. Valadan Zoej, 14–16 October 2005). Along with traditional use of remote sensing, GNSS, cartography maps based data, VGI generates mobile information by GPS technology and camera having mobile sensors. It is used by the non-technical internet users in contemporary increased production of data for recovery efforts on disaster (Rajabifard, Feeney, & Williamson, 9–12 May 2004).

- **Spatial Data Infrastructure**
-

There are challenges of sharing of spatial data which are overcome by the use of Spatial Data Infrastructure (SDI). However such data sharing system need established technology and standard data management for easy and rapid use of the data by the technical staffs involved in institutions of risk and disaster management. The use of SDIs can be many, among which development of risk assessment, planning for relocation and to support and establish plans for disaster management for potential disaster minimization are the prominent ones. SDIs in disaster management also aid the access of spatial information through web-based technology involving disaster management organizations. They are involved as main stakeholders active in producing, updating, maintaining and sharing such spatial datasets required for response activities among a wider community of disaster management (Rajabifard & Williamson, 22–27 September 2003).

Such spatial databases are used by the governmental and non-governmental organizations as a framework enabling for interoperability, exchange, access and data distribution though communication technologies. It increases efficient and effective data management from mitigation to the preparedness, response and recovery phases but focuses primarily on developing preparedness actions and mitigation of natural disasters ("Brasil Ministério do Planejamento, Orçamento e Gestão," 2012)Though there are spatial data infrastructures that integrate spatial data but there are areas lacking public policies that support data sharing for disaster management. Contradicting this, an example is a National Spatial Data Infrastructure created by the Brazilian government in 2008 for putting together technologies policies, mechanism and procedures in an integrated setting. It is used to coordinate, monitor, disseminate and use public-produced geospatial data and facilitate data sharing. Similarly, comparatively little technical knowledge is required to access data, metadata and geospatial information with permits from international protocols from internet services such as GeoWeb Services (Manfré et al., 2012)

An open data national infrastructure development and use of digital nets is important for transparency and accessibility of government information to the citizens is discussed in assemblies of the United Nations by the representatives of countries. Political deals allow for information sharing through established

cooperatives of international SDI where importance is towards quality, interpretation for correct usage of information. This requires standardized methodologies and well prepared technical staffs for analysis and activities (Manfré et al., 2012)

- **Crowdsourcing**
-

Crowdsourcing is a work of sharing and distributing of information completed through a distributed groups of people. It is used for producing detailed reports for development projects, mapping the areas of vulnerability for disaster risk reduction and providing direct aid during response stage (Chapman, 2013).

- **Volunteer Geographic Information (VGI)**

In the past, the official institutes were responsible for creating geographical information, whereas at present the ordinary citizens with or without formal education. They are voluntarily active replicating the human behavior in the advent of new technology resulting to accurate or not so accurate information (M.F. Goodchild, 2007b). Individuals as humans themselves can behave as sensors because of the fact that in their lifetime they acquire knowledge on places of their residence, work, visits, topographic features and the network of transport to reach those places (M.F. Goodchild, 2007c). A person's experiences equip in them the abilities to interpret and integrate and through this ability they are considered as an intelligent mobile sensor. Such abilities are enhanced by the use of GPS mobile phones with embedded GPS including digital cameras and tracking devices (Manfré et al., 2012).

Maps are important for the emergency situations as spatial data are used to locate, identify and recognize the objects of need in the affected areas, to mitigate the problem by action planning such as route rescue, relocation, food and medicine distribution etc. Disasters can highly modify an area after the destruction making the conventional maps made before the disaster ineffective. VGI has great value due to its quick communication reducing the wastage of time. It however requires promotion in resource investment, training and coordination activities by government leaders and civil society (Council, 2007). VGI helps to obtain collective geographic information from volunteers of ordinary citizens without qualification needs (M.F. Goodchild, 2007a).

Citizen provided information facilitates the disaster management system by improving it. Besides training activities, such citizens or communities living in risk areas involved in volunteering for information acquisition and aid activities during the severe events should be in a minimum number (Manfré et al., 2012). VGI data contributed facts in more-populated areas are comparatively more accurate than the less-populated areas. Such data is revised to reduce errors by a volunteer group (Elwood & Goodchild, 2012). The scientific community should be establishing the methodology to assess and reliability of VGI related data. SDI data will be enhanced by implementing VGI systems to improve the time during emergency response enabling managers with action plan, alert system identification and citizens with information accessibility. However developing countries need an increase in financial support for research in this area for developing methodologies, techniques and relevant procedures for areas depending upon their specific events. The financial matters of damage recovery should be involved to invest in such studies (Manfré et al., 2012).

- **Web Services**

There are examples in disaster situations where online volunteer maps come up after the event where the damage areas are marked with dots in the Google Maps linked with information related to its characteristics (Roche, Propeck-Zimmermann, & Mericskay, 2011). Webpages such as WikiMapia, OpenStreetMap, GeoCommons etc that contribute to wide range of geographic information have had rapid increase. Their use in GIS is relevant with the presence of functions like data acquisition, storage,

modeling and mapping/visualization. It is especially efficient in data production because use of such webpages have changed individual's behavior towards the vast range of online geo-information. The change in human behavior is acquired through change in their use from being passive to active in the production and sharing of data (Sui, 2008).

Volunteer mapping websites such as Wikimapa, WikiCrimes, and OpenStreetMap Brazil shows its emerging experiences with VGI. There is a recent distribution of Volunteer data on natural disasters of Brazil in the internet in the website that consists of a map with information on damage of disaster. The users can bring added value by posting forms of information such as photographs, videos, reports of the disaster through Google Maps database (ECO, 2012). Simple interfaces of the services such as Google Earth and its combination with the available high-resolution satellite images enable the ordinary people without professional qualifications to provide effective spatial data (M.F. Goodchild, 2006). Individuals mobilize themselves and produce volunteer maps on damage updates which later have huge amount of hits resulting to various information such as location of damage, evacuation orders, emergency shelters etc (M.F. Goodchild & Glennon, 2010).

Brazil created the Disaster Map in 2009 based on Google Maps displaying texts, photographs, videos and links on catastrophic events as a result of their occurrence (Disaster.Map, 2012). Experiences from Brazil disaster shows that there is an increase of involvement among people and civil society in collection, sharing and dissemination of data and information through the resourceful VGI within few hours of disaster occurrence to save human lives (Manfré et al., 2012).

- **Open source**

There is a lack of localized information of the affected areas in the aftermath of disaster. The free use of such information is possible through low-cost-high-tech tools of open-source mapping. An example is the case of the devastating typhoon Haiyan in the Philippines, where the access of localized high-resolution information assist the communities with the help from over 766 volunteers activated through Humanitarian OpenStreetMap team. This baseline geographic data could be freely used by the government of Philippines and donor as well as partner organizations in the recovery activities. OSM in Haiti 2010 has produced detailed information for guiding search and rescue teams, for locating emergency centers and for planning activities of resettlement. Similarly, participatory mapping in Jakarta has produced detailed neighbourhood maps including administrative boundaries, shelters, logistic centers, evacuation routes and inforation on disaster exposed communities and buildings. These are for the use of the local authorities for inputs in contingency planning and disaster preparedness (Geddes, 2014).

Open systems that enable sharing of data among the wide range of actors to be able to participate in a transparent and accountable environment important for building resilience. For eg: The Open Data for Resilience Initiative (OpenDRI) provides better information and tools that empower decision-makers to reduce the impact of disasters. OpenDRI following Haiti 2010 earthquake enabled the people to collaborate and utilize the downloaded data contributed by the individuals and organizations for risk assessment to rebuild Haiti. Similarly free and open source software through realistic natural hazard impact scenarios work for planning, preparedness and response activities including insights for disaster events in the future (GFDRR, 2014).

- **Social Media**

Developed in 2008, Ushahidi was used in crisis management of natural disasters allowing sharing abilities among anyone to generate dynamic maps via SMS, emails or other forms of information. As a free platform and open-source application, it integrates Web services including mapping, databases, management tools and visual functionality etc. It was used in Haiti 2010 and Christchurch 2011 for support provision to authorities, non-government organizations (NGOs) and victims in the response phase (Roche et al., 2011). Maps and other tools are used for transmitting the status of crisis information to the people through examples such as Google Crisis Response enhancing disaster response and post-disaster recovery results (Google.org).

Internet has contributed to easy access to the available geo-technology such as software of GIS and satellite images. Other tools for easy access are GPS popularization through citizen participation using VGI for disaster management. More SDIs should be created and maintained by institutions who extract spatial data for information for the management of risk and disasters. The exchange of data depends on the properly established political deals and agreements (Manfré et al., 2012).

Socially accepted mitigation measures are the outcome of their integration with hazard-vulnerability-risk chain. They require such assessment techniques, analytical tools through geo-spatial data integration and standardization (Fabbri, 2005). Similar activity of social resilience is generated by the social media like Twitter having similar quality as that of face-to-face interactions for communication during crisis. They have additional benefit as they can foster through creation of new relations (Meier, 2013). The reason is that under difficult conditions, there seems and increment in social capital. Similar to the social ties in the real community, the virtual dense community can also implement faster recovery if provided they work on norms, information and trust (Meier, 2012).

- **Participatory Mapping**

Community based Mapping is done through working directly with the communities creating multi-purpose maps with disaster preparedness. Similarly, Hybrid participatory Mapping is done by engaging local government with the trained. University student mappers supported by the quality control from the national mapping agency. OpenStreetMap, a crowdsourcing application is an open source tool having free and open access of users from an active global community who upload and host data for online and offline mapping (Baca, 2012). There are key requirements to collect base data for preparedness with OpenStreetMap are High Resolution Imagery, clear guidelines of the mapping entity, information on the suitable use of data as well as monitoring of results (Chapman, 2012).Various forms of geo-information ranging from paper maps to analytic and simulation digital models is used in all phases of disaster management but the professionals themselves have difficulty in reading them The reason is the lack of the knowledge of Geo-ICT (S. Zlatanova & Fabbri, 2009).

Grassroots Unmanned Aerial Vehicle (xUAV) is used by the grassroots communities. It supports the locally-led efforts for disaster response and in addition transfers skills of maths, science and engineering to the local communities to develop multiple local partners. Similar to the Public Participatory GIS (PPGIS), xUAV expects the grassroots approach to advance to Public participator UAVs by making use of geospatial information systems and technologies (Meier, 2014a).

### 2.3.3. Geo-information in Disaster Risk Management

GIS, remote-sensing and GNSS data when integrated give an overview of the controlling factors of seismicity and earthquake effects on ground and infrastructure enhancing the understanding of geological and geomorphological aspects. Such information integration support humanitarian agencies involved in relief activities through compilation of natural disaster databases (Giardino, Perotti, Lanfranco, & Perrone, 2012). However, the information and methodologies of their application should be shared and adapted as per the context with the assistance from trained technical staff of risk and disaster management centers. There are instances where remote-sensing data is applied to analyze post-disaster to study the process of disaster for establishing preventive plans (Dias, Batista, & Catelani, 2011). Similarly, web-based GIS model is developed by risk area mapping and is applied for conducting activities for emergency response (Barbosa, Oliveira, & Alves, 30 April–5 May 2011). The observation of satellite imagery for disaster management complement the on-site measures through their products to analyse and fulfil the demands of operation of other systems e.g. decision support systems (Tralli, Blom, Zlotnicki, Donnellan, & Evans, 2005). IKONOS and Quickbird images was proposed as a quick-response to identify damaged buildings and land-use changes in a post-tsunami disaster (Wikantika, Sinaga, Hadi, & Darmawan, 2007). Similarly, Moderate-resolution satellite (MODIS) images can provide rapid assessments of severe damage to land resources but cannot determine the land cover type (Belward et al., 2007).

Out-space technologies such as Global Positioning System (GPS) applicable for providing precise geographical location information is used for management related, preventive and emergency situations (Manfré et al., 2012). GPS technology is also used or monitoring the geophysical phenomenon of disasters (Hastaoglu & Sanli, 2011). In addition, portable navigation receivers are used for mapping activities post disaster (Yang, Rau, Yu, & Yu, 2000). Similarly, GNSS includes GEO-PICTURES as proposed in the study, as a system with integration of satellite images, *in-situ* sensors, geo-tagged pictures, text and varieties of other applicable information preferably missing for remote-sensing analysis (Diaz-Delgado & Pons, 2001). However there the technical difficulties in availing real-time satellite data and imagery such as spatial, spectral and temporal resolution, spatial coverage as well as 2D and 3D capacity and the capability of interpreting and extracting information from them (Zhang & Kerle, 2008 ). Such difficulty of limitation in spatial resolution is overcome by land-based mobile mapping systems for real-time rapid acquisition of detailed geospatial data. Data collection is done through individual involvement. Similarly on-site investigation is supported by terrestrial mobile mapping systems in urban areas during emergency response activities for disaster management (J.; Li & Chapma, 2008). Infrastructure assessment is done using multi-sector and multi-temporal remote sensing imagery using near-real-time analysis by evaluating the usability of roads for immediate use after the disaster (Butenuth, Frey, Nielsen, & Skriver, 2011). Similarly study showed that Light Detection and Ranging (LIDAR) can be used for detection of obstructions of transport network in pre and post disaster for producing routing schemes for reducing response activities (Kwan & Ransberger, 2010).

The applications used frequently in the pre and post disaster activities make frequent use of techniques and tools such as remote-sensing, GIS and GNSS (Manfré et al., 2012).There is a significant role in spatial information in the emerging science of risk and disaster management with the rapid utilization of geo-information. The multiple availability of GIS analytical tool will help disaster management become a fully spatially-oriented discipline (S. Zlatanova & Fabbri, 2009). For the Risk assessment during Pre-disaster elements at risk and hazard maps are a necessity. They are the result of high resolution image, data on wards and census, digital elevation model (DEM) lidar as well as the thematic layers. Altogether they produce the risk maps. Similarly, for the Post Disaster for Damage assessment the data on disaster footprint and exposure are a must (Ezzine, 2012). In rescue and recovery, standardized data formats are essential for timely information flow for minimizing destruction to lives and property (Haarbrink & Shutko, 2005). Mitigation and preparedness efforts focus on disaster prevention activities through application in land-use planning and identification of areas of vulnerability. Information of remote sensing are analysed through GIS techniques. Land cover maps developed through satellite images and the information on geology, topography, geomorphology and climatology are combined to provide risk assessments. Remote-sensing techniques are widely used to detect the changes in land cover in the response and recovery phases of earthquake disasters (Manfré et al., 2012). In case of emergency response, the initial information derived from remote-sensing data within three days of disaster occurrence is the disaster type, location and rough magnitude. Secondly, the information on refined magnitude and the extent of damage is extracted. Police or media are involved in the preliminary aerial survey. In addition, aerial photography survey is done and Digital elevation Model (DEM) is generated and to study the changes, it is also integrated with pre-disaster data (Kerle, Heuel, & Pfeife, 2008).

- **Disaster Risk Management Cycle and Geo-information**

The geographic information system (GIS) is able to integrate the information of hazards and social aspects making it an ideal assessment tool to provision for the efforts in planning of community hazard. The results of the analysis from GIS ad the decision makers to limit themselves with the resources and make use according to their priority to increase community resilience (Wood & Good, 2004). Geo-information as a support system in the form of maps and simulations are used in all phases of disaster management since all the information is connected spatially. Scenarios are also developed out of the simulations used for the purpose of mitigation during preparedness, especially in training programs. It is also useful during recovery phase where there is a high interest for the public (Abdulharis, Hakim, Riqqi, & Zlatanova, 2005, September ). Data availability, finding appropriate data and having cooperative systems are the constraints in geo-information having scattered in different organizations, systems as well as having formatted and applicable differently to different tasks (S Zlatanova, 2005). The reason being proprietary

standards and developments leading to disability of the organizations to work together and unable to deliver services to multiple user groups (Abdulharis et al., 2005, September ).

The systematic creation and maintenance of on-time, accurate and relevant geo-information is the necessity of disaster management. The varieties of technologies of geo-information aids to manage and recover in hazards ranging from accidents to disasters as catastrophic as earthquake. They are contextual technologies providing information and emergency services for public welfare. Geo-Information infrastructures for e.g. Infrastructure for Spatial Information in Europe (INSPIRE) with variable semantics of ISO, OpenGIS standards etc brings complications regarding real-time processing of data in times of stress (Oosterom, Zlatanova, & Fendel, 2005).

In disaster management, geo-information or spatial data are considered the foundation for decision making in minimizing losses and saving of lives. Foremost requirement is that the data and required information products should be available and in the usable form and time. Similarly the technological services must be application, user and specific environment oriented. Local Spatial Data Infrastructure (SDI) is developed under geo-information department of Disaster Management having a cooperative and reconciling network of administrative agencies such as suppliers of data and software, scientific institutions and geo-information users (Köhler, 2005). A SDI consists of spatial data, standards, networks and policies which are technical and therefore critical. One of the reason is the formal semantics of data (S. Zlatanova & Fabbri, 2009).

The Earth Observation (EO) capabilities in Disaster Management Cycle (DRM) are as follows:
Emergency Response

- Rapid Crisis Mapping and Damage Assessment
- Situation Mapping

Prevention, Preparedness, Recovery, Reconstruction

- Detailed Damage Mapping
- Risks Assessment

All phases

- Reference mapping
- Digital Elevation and Digital Terrain Models
- LU/LC Cover Mapping
- Asset Mapping

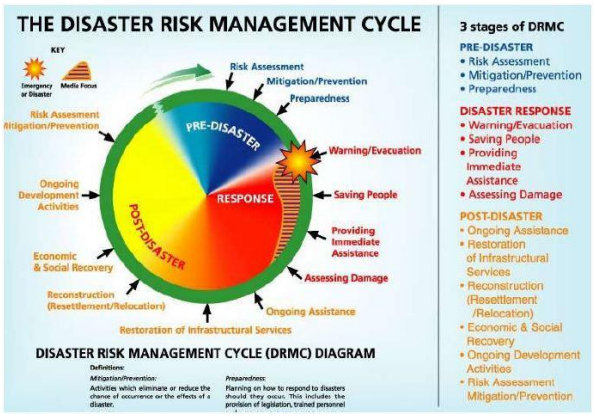


Figure 9 The Disaster Risk Management Cycle

The Exposure/Asset Mapping/ Asset Modelling consists of a wealth of types of information from various areas. Hazard mapping includes scientific data that characterise and monitor hazards, operate damage zoning through rapid information for obtaining hazard impacts, similarly information on hazard risk through risk inventory (Bally, 2012). Data on population densities, building surveys from bureau of statistics and local data from public sources such as OpenStreetMap are extracted (Baca, 2012).

It is important that the agencies share information for planning together to develop mitigation strategies for preparation in joint manner. It is facilitated by the GIS tool. Analysis of the complex problems are dealt by GIS in a graphic form for effective communication and understanding for creation of a common language, vision and understanding of problem and priority needs (Johnson, 2005).

## 2.4. Conclusion

The chapter is focussed on information related to the ways in which geo-information is used in earthquake disaster and how resilience can be attributed to it for a sustainable community. The various methods and technology of the contemporary geo-information and disaster based issues are dealt. The literature is further applied in the following chapter by building a framework of community resilience.

# 3. FRAMEWORK OF COMMUNITY RESILIENCE AND LESSONS LEARNT IN EARTHQUAKE DISASTER

This chapter focuses on the products and services used in the various institutions involved in Disaster Risk Management sector. These are geo-information products and services, technology and tools used in the contemporary scenario. They are discussed from lessons learned from the earthquakes and geo-information use in Haiti and Wenchuan. The framework is an amalgamation of the institutions involved in the production, sharing and use of the products and services of geo-information in the various resilience phases.

## 3.1. Geo-information in Earthquake Diasater

The information and awareness of the existing resources, types of data, availability and accessibility are insufficient as studied from the past disasters (H. Brecht, 2006; Kevany, 2005). The absence of spatial data infrastructure is an obstacle to availability of quick data, its access and transfer. It is an appropriate measure taken before the disaster for storing of prior information as well as the dynamic information that becomes available after the disaster. This needs continuous monitoring of changes and developments and distribution of information (S. Zlatanova & Fabbri, 2009).

They should also use intuitive interfaces since unfamiliar working systems bring delays while operating in such life threatening situations. Various mobile systems and sensor networks are used for monitoring disasters and to support decision making. Therefore various groups of systems are used namely scenario-based systems or demand-based systems. Scenario-based systems approach organizes integrated data management making use of historical records. It creates modelling and simulation methods and integrates them, develops and adapts scenarios through calibration and validation techniques. Similarly, advanced optimization tools support them for forecasting process. Such specifically prepared datasets and models and their applications are used for early warning and the sensor information such as areas where population should be warned are visualized through several modes such as Google Earth using various types of GIS information. Demand-based systems are developed at local and regional levels and are responsible for command and control involving various domains involved in a particular disaster. They focus on communication and sharing of information such as distributed and dynamic data. An example is Open Geospatial Consortium (OGC), OpenWeb Services (OWS) (S. Zlatanova & Fabbri, 2009).

The relationships between the non-spatial data can be represented spatially by enhancing the information geographically. Humans think geographically as they have relationship to location and make decisions accordingly. Geo-information helps to understand geography for better decision making. It helps to do earthquake hazard mapping and further analysis to gather information for undertaking plans and programs for managing disaster preparedness. For example, a program dedicated towards analyzing the location of demography and infrastructure is an urban information system which is a part of GIS (geo-information system). In addition, GIS can perform earthquake loss estimation modelling which incorporates the combination of spatially distributed data with a number of attributes or characteristics such as non-spatial data. It provides an overview of the implications distributed among the localized communities with the impact of damage due to disaster. Maps and advanced simulations can be used in the form of geo-information in all the phases of disaster management to predict the risk and potential damage. The equal importance of GIS component in such a scenario is due to the need of spatially related information (ESRI, 2007).

## 3.2. Framework of Community Resilience

The framework of community resilience adopts the Hyogo Framework strategic goal and priorities for action. They are as follows:

- The development and strengthening of institutions, mechanism and capacities to build resilience to hazards.
- The use of knowledge, innovation and education to build a culture of safety and resilience at all levels.

Their dimensions are institutional resilience and the use of geo-information in disaster. It focuses on the following elements and their entities:

Table 1 Elements and Entities for Community Resilience

| Elements | Entities |
|---|---|
| • Social Capital: Social ties (norms, information and trust), under difficult conditions, there seems and increment in social capital | Semantic and standard use of terminology for geo-information in GIS |
| • Social Resilience: Foster through creation of new relations for communication for social resilience | Crowdsourcing e.g: Social media (Twitter) similar to face-to-face interactions |
| • Resilience: Open systems for building resilience | Open Data for Resilience Initiative (OpenDRI) |

The use of geo-information emphasizes on data availability, finding appropriate data, cooperative systems, and proprietary standards among different organizations. Similarly the emphasis is on on-time, accurate and relevant availability of data/geo-information products in the usable form and time. It is seen in the work of Kathmandu Living Labs which uses OpenStreetMaps that focuses on Open Data Community.

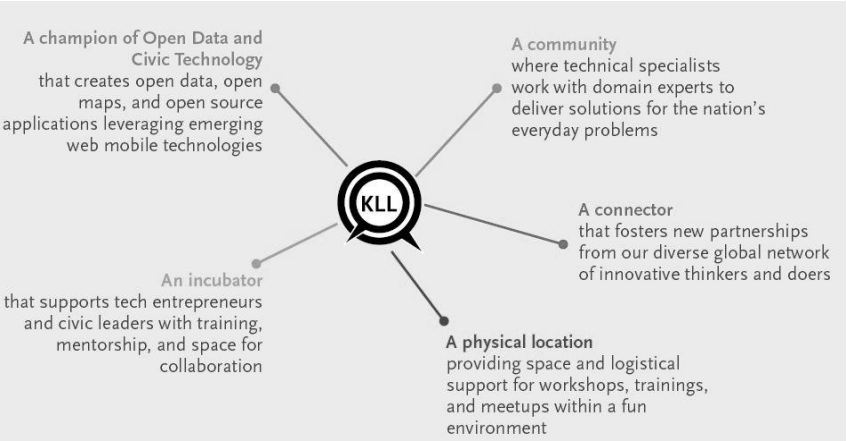



Figure 10 About Kathmandu Living Labs (KLL, 2014)

## 3.3. Production, Sharing and Use of Products and Services for Disaster Risk Management Cycle

### 3.3.1. Preparedness

The risk assessment can be developed and delivered my making use of satellite remote sensing data. It can be accessible through web. They can be public domain data or commercial imagery which are purchased through reseller companies. The risk maps are prepared through the scientific information, their analysis and modelling. The thematic and baseline data and their up-to-date layers are extracted from the space based information effectively. The interpretation of the field surveys, topographic maps and thematic maps are done through satellite images. In addition, there is need of spatial data to serve pre-disaster activities. The attributes of the spatial data are linked with the non-spatial and field data. This is used for visualization and modelling based on maps (Ajmar, Giulio Tonolo, & Perez, 2010).

Preventive actions are established through various measures. Early warning systems and risk management use near real-time satellite data. Early-impact analysis is done in done in the form of cartographic products. Similarly, geographic datasets with precise and accurate reference is made for the extraction of value added information (Ajmar et al., 2010). Map based modelling is a primary requirement for prevention. Input to access risks is provided by baseline data for the identification of hazard prone areas, locations and vulnerabilities. In addition they also help in preparation of plans used for risk management, early warning and for preparedness. Hazard map provides wit the location of the specified area of risk (Ravan, 2010). Similarly, high resolution aerial imagery benefits in topography mapping (Kidd, McCallum, & Ishadamy, 2010). Preparation and operation structures should be managed for an emergency event or disaster. These include among others, environmental factors and network connectivity (Ajmar et al., 2010).

| | **Geo-information Components** | **Production** | **Shared** | **Used** |
|---|---|---|---|---|
| **Preparation: Plans and Policies** | • Develop and Deliver risk assessment (Ajmar et al., 2010) | | | |
| | Risk maps (Ravan, 2010)<br>-Satellite images<br>-Maps (Light Detection and Ranging LIDAR) | International Charter Space, funding agencies, reseller companies, Scientific information | Web services (OpenWeb Services (OWS)) | Government and Non-Government Organizations |
| | Spatial data (Ravan, 2010)<br>-Satellite Remote Sensing Data | International Charter Space, funding agencies, reseller companies | Web services (OpenWeb Services (OWS)) | Government and Non-Government Organizations Regional and Local Government (J. Li, Li, & Chapman, 2005. ) |
| | -Spatial Data Infrastructure Standards (SDI) | National Government, SDI framework based agencies, programmes and projects | Web map servers | Wider community of disaster management: Government and Non-Government Organizations |
| | • Establish preventive actions (Ajmar et al., 2010) | | | |
| | -Map based modelling (Ravan, 2010)<br>Maps and simulations (Geo-information support system)<br>Scenarios developed from simulations *(training)* | Scientific institution | National Government, Disaster Portals | Government and Non-Government Organizations |
| | -Baseline data (Ravan, 2010) | Space based information Technical Profile (S. Zlatanova, 2013) | Upon registration via Internet, Disaster Portals (S. Zlatanova, 2013) | Local and Regional Government (S. Zlatanova, 2013) |
| | -Utility and infrastructure data (Ravan, 2010) | | | |
| | -Hazard maps (Ravan, 2010) | Local Government, Local Administrators, | NGOs, Social groups, Community groups | Government and Non- |

| | | | | |
|---|---|---|---|---|
| | | Community involvement | | Government Organizations |
| | -Thematic Maps | Scientific inputs (information), Technical Profile (S. Zlatanova, 2013) | Upon registration via Internet, Disaster Portals (S. Zlatanova, 2013) | Local and Regional Government (S. Zlatanova, 2013) |
| | -High Resolution Aerial Imagery for Topographic Mapping (Kidd et al., 2010)<br>Digital base map: Combining Digital terrain model (DTM) and digital orthophotos | Agencies for International Development | National Coordinating Agency for Surveys and Mapping (Spatial Information and Mapping Centre) | National Government, Local Government, Community, Aid and Recovery Community (Kidd et al., 2010) |
| | -Orthophoto data | | | National Government, Non-Government Organizations (NGO), United nations (UN) and International Organizations (IO) |
| | • Prepare the operative structures for managing an eventful emergency event or disaster (Ajmar et al., 2010) | | | |
| | -Environmental factors and Network connectivity (Ajmar et al., 2010) | Sensors and Database (Laurini, Servigne, & Noel, 2005) | Control System: telecommunication System (satellite-based, cellular phones attached to sensors) (Laurini et al., 2005) | Military Applications, Disaster management Organization (Laurini et al., 2005) |

Table 2 Geo-information production, shared and used among various Institutions in Preparation phase of Resilience

### 3.3.2. Response

The actions are executed on priority basis, firstly by saving lives and secondly by putting attention towards social and economic recovery. Rapid mapping activities are conducted (Ajmar et al., 2010). Satellite images from near real-real time coverage are used through its integration with spatial data for mapping earthquake impact (Ravan, 2010). Also "International Charter for Space and Major Disaster" is used for integrating map products, metadata and standard formatting for responding phase. Initial assessment of population affected is done by using both optical and radar medium/low resolution satellite data (Ajmar et al., 2010).

The maps undergo pre-assessment for data preparation. It includes image indexing for searching the image quickly. Data pre-processing is done for image consistency. The information is extracted and is continued by map making (S. Li et al., 2010). It is followed by Initial Damage Assessment for emergency response activities. They include Search and Rescue (SAR) operations, reestablishment of main logistic routes, management, coordination and sharing of information, provision of humanitarian assistance and initial damage and need assessment. Optical Remote Sensing and Rader remote Sensing also assist in this stage of response. Similarly manual interpretation assist in mapping with the involvement of a large volunteer

crew (Ajmar, Boccardo, Giulio Tonolo, & Veloso, 2011). Such data are delivered via attachments to the pre-defined mailing list, included in the web pages and portals involved in emergency management.

Rapid estimation of the population affected is taken with the help of LandScan Global Population dataset (Dobson, 2000). They require the updated local census datasets (Ajmar et al., 2010). Spatial data used for post disaster activities are interpreted from satellite images. They are dynamic data such as near-real time data and static data such as baseline data (Ravan, 2010). Baseline data help locating hazard affected areas. Examples of the data types are inventory, demography, socio-economic parameters of affected population, rescue services and amenities (Ajmar et al., 2010). Availability of remotely sensed data has become a valuable post-earthquake damage assessment tool. Rapid disaster response is also served well by Google image and OGC compliant Web services workable in GIS environment (Ajmar et al., 2011). It is also facilitated by Rapid Impact Analysis Map through various techniques such as Participatory Mapping either on ground or through media, namely OpenStreetMap, Google Map Maker etc. Ground surveys are done through low cost devices and tools such as LCMMS (Low Cost Mobile Mapping System) (Ajmar et al., 2011). There are also automatic or semi-automatic methods for data processing (S. Li et al., 2010).

Table 3 Geo-information production, shared and used among various Institutions in Coping phase of Resilience

| | Geo-information Components | Produced | Shared | Used |
|---|---|---|---|---|
| **Coping: Initial Damage Assessment** | • Execution of actions planned firstly on saving lives, secondly on social and economic recovery (Ajmar et al., 2010) | | | |
| | -Rapid mapping activities (Ajmar et al., 2010) | Space Technology, Space Agencies (Ajmar et al., 2010) | Web services, Reseller Companies (Ajmar et al., 2010) | Authorized users: Humanitarian and Government entities (Ajmar et al., 2010) |
| | -Initial assessment of affected population (Ajmar et al., 2010)<br>Fastest quake relief efforts Emergency Response (S. Li et al., 2010) | Global Population Dataset (Ajmar et al., 2010), National Government (National Disaster Relief Contingency Plan) (S. Li et al., 2010), Local Government (Local Census Datasets) (Ajmar et al., 2010) | E-mail, web page, Portals on Emergency Management (Ajmar et al., 2010) | Humanitarian Management Organization (Ajmar et al., 2010) |
| | -Pre-assessment maps for data preparation (S. Li et al., 2010)<br>Satellite Imagery | International and Domestic Data providers (International Charter "Space and Major Disasters") | OGC compliant Web Services (Ajmar et al., 2011) | Humanitarian Organizations, UN agencies (Ajmar et al., 2011) |
| | -Initial Damage Assessment (Ajmar et al., 2011) | International Charter "Space and Major Disasters, Government Entities (Ajmar et al., 2010) | Government Entities and UN agencies (Ajmar et al., 2010) | Humanitarian Organizations, UN agencies (Ajmar et al., 2011) |
| | -Manual interpretation for mapping involving large crew of volunteers (Ajmar et al., 2011) | Individuals (S. Li et al., 2010) | National Government (S. Li et al., 2010) | Authorized users: Government and Non-Government Organizations (Ajmar et al., 2010) |
| | • Rapid estimate of affected population (Dobson, 2000) using updated local census datasets (Ajmar et al., 2010) | | | |
| | -Rapid estimate of affected population using updated local census datasets | National Statistical Office, Research Institution, Local/Expert Knowledge (Schneiderbauer & Ehrlich, 2005) | Research Community (Schneiderbauer & Ehrlich, 2005) | Public (Schneiderbauer & Ehrlich, 2005) |

| | | | | |
|---|---|---|---|---|
| | -Spatial data (Ajmar et al., 2010)<br>Near real-time satellite data; optical and radar data | Satellite/aerial data providers<br>DigitalGlobe (optical satellite data) and World Bank ImageCat-RIT (aerial imagery, including thermal and lidar acquisitions) (Ajmar et al., 2011), Space agencies and funding agencies | Community of Web map servers (Ravan, 2010) | Regional and Local Government (J. Li, Li, & Chapman, 2005)<br>Police, Rescue team or Relief Organizations (Schneiderbauer & Ehrlich, 2005) |
| | -Baseline data (Raw data)(Ajmar et al., 2010)<br>Geographic data | Comprehensive Spatial Database in NDRCC<br>Ad-hoc web application (Ajmar et al., 2011) | Web pages: Specific GeoRSS portals (Ajmar et al., 2011) | GIS specialists (Ajmar et al., 2011) |
| | -Remotely sensed data (Ajmar et al., 2011) | Satellite/ aerial data providers (Ajmar et al., 2011) | Good coordinating bodies with proper supporting tools (Ajmar et al., 2011) | Humanitarian Community (Ajmar et al., 2011) |
| | -Rapid Impact Analysis (Ajmar et al., 2011)<br>Map Products | Non-Profit Association, Information Technology for Humanitarian Assistance, Cooperation and Action (ITHACA) (Ajmar et al., 2011) | United Nations World Food Program (UN WFP) (Ajmar et al., 2011) | Humanitarian Organizations, Community (Ajmar et al., 2011), Central Government Emergency Management Agencies, Local Government, Field Teams, Public and International Societies, professional Institutions: Scientific research (S. Li et al., 2010) |
| | -Participatory Mapping (Ajmar et al., 2011) | Individuals, Community (S. Li et al., 2010) | National Government (S. Li et al., 2010) | Authorized users: Government and Non-Government Organizations (Ajmar et al., 2010) |
| | -Ground surveys (Ajmar et al., 2011) | Non-Profit Association (Ajmar et al., 2011) | GIS customized software (Ajmar et al., 2011) | United Nations World Food Program (UN WFP) (Ajmar et al., 2011) |

### 3.3.3. Relief/Recovery

"To provide effective and timely support information for disaster emergency rescue and relief, the information extraction should be completed within hours after the image were acquired (S. Li et al., 2010)". In the relief and recovery stage access to geospatial reference data from Spatial Data Infrastructure (SDI) becomes a priority. SDI combines the tools for spatial data discovery, evaluation, downloading and application, internationally shared pre-defined representation and rules (Ajmar et al., 2010). Spatial data serve the activities related to post disaster (Ravan, 2010). High Resolution Aerial Imagery such as ortho photos along with topographic data is beneficial for disaster recovery. Rehabilitation and reconstruction activities are supported by such information for relief and spatial location of man-made and natural features (Kidd et al., 2010).

Post-earthquake damage assessment uses remote sensing technology for satellite and high resolution imagery for Detailed Damage Assessment (Ajmar et al., 2011). The satellite data is used for multi temporal comparison for comparing the post-event imagery. Google high resolution aerial imagery is also used to update the satellite data (Ajmar et al., 2011). Airborne remote sensing images, unmanned airborne remote sensing images, field investigation data and daily statistics data are the form of information for disaster relief and recovery (S. Li et al., 2010). Participatory Mapping is done through medias such as OpenStreetMap, Google Map Maker (Ajmar et al., 2011).

Table 4 Geo-information production, shared and used among various Institutions in Recovery phase of Resilience

| | **Geo-information Components** | **Production** | **Shared** | **Used** |
|---|---|---|---|---|
| **Recovery: Detailed Damage Assessment** | • Access to geospatial reference data through SDI (Ajmar et al., 2010). | | | |
| | - Spatial data serving post-disaster activities (Ravan, 2010) | UN platform for Space based Information for Disaster Management and Emergency Response (UN-SPIDER) (Ravan, 2010) | Geo-information Technology Community (Lemmens, 2005) | Regional and Local Government (J. Li et al., 2005. ), Insurances, services (Firchau & Wiechert, 2005) |
| | • High Resolution Aerial Imagery (Kidd et al., 2010). | | | |
| | -Topographic data (Kidd et al., 2010). | International Charter "Space and Major Disasters: Eg Quickbird satellite image (Demarchi & Facello, 2013) | Geographic Information System, Technical Profile (Demarchi & Facello, 2013) | Regional and Local Government (J. Li et al., 2005. ) |
| | -Post earthquake damage assessment (Detailed Damage Assessment) (Ajmar et al., 2011). | | | |
| | -Multi temporal comparison (Ajmar et al., 2011) | | | |
| | -Google high resolution aerial imagery (Ajmar et al., 2011) | Google (Google Earth/Map) (Ajmar et al., 2011) | OGC compliant Web Services (Ajmar et al., 2011) | Global Disaster Management Organization, Community and Individuals |

| | | | | |
|---|---|---|---|---|
| | -Airborne remote sensing images (S. Li et al., 2010) | National Surveying and Mapping Agency, National Academy of Sciences (S. Li et al., 2010) | Geo-information Technology Community (Lemmens, 2005) | Disaster Management Organizations, Commercial Firms, Citizens (Lemmens, 2005) |
| | -Unmanned Airborne Remote Sensing Images (S. Li et al., 2010) | National disaster Reduction Centre (NDRCC) (S. Li et al., 2010), Civil Community (Lewyckyj & Everaerts, 2005a) | Internet (Lewyckyj & Everaerts, 2005a) | Earth observation for Mapping and Risk management Organizations on Earthquake Disaster (Lewyckyj & Everaerts, 2005a) |
| | -Field investigation information (S. Li et al., 2010) | Field Teams (S. Li et al., 2010) | UN Agencies, Government Organizations and Humanitarian Community Coordination Bodies (Ajmar et al., 2011) | Humanitarian Community (Ajmar et al., 2011) |
| | -Daily statistic disaster information (data acquisitions) (S. Li et al., 2010) | Local Governments (S. Li et al., 2010) | National Government | Disaster Management Organizations, Humanitarian Community |
| | • Participatory Mapping (Ajmar et al., 2011) | | | |
| | -Volunteer Mapping | Mapping Community, Individuals | Web services (OpenWeb Services (OWS)) | Authorized users: Government and Non-Government Organizations (Ajmar et al., 2010) |

#### 3.3.4. Mitigation

Data classification is done (Ajmar et al., 2010) by using the data layers such as baseline data layers, utility and infrastructure data layers, disaster specific data layers, thematic data on terrain and natural resources, near-real time satellite data and thematic maps etc (Ravan, 2010). Data discovery that goes through discovery phases involving map integration of map products with suitable metadata a format of standard form (Ajmar et al., 2010). Data integration requires GIS based baseline and thematic spatial data with uniform data standards. Both central and risk related baseline and thematic data are integrated. Spatial data are used for providing service in the post-disaster activities (Ravan, 2010).

Data sharing (Ajmar et al., 2010) by adopting Spatial data infrastructure and standards to improve integration and sharing of data. In addition framework of SDI with specific standards assists for easy data access and sharing. The use and improve in the access of space based information in disaster management is done by its integration with spatial data. Data sharing is done by enterprise GIS and web mapping services (Ravan, 2010).

The inventory of space resources should be compiled. The emergency procedure must be scientifically based for effectiveness. Social resources must be mobilized. Furthermore integration of images with social information, statistical disaster information and field investigation is important (S. Li et al., 2010).

Table 5 Geo-information production, shared and used among various Institutions in Adaptation phase of Resilience

| | **Geo-information Components** | **Production** | **Shared** | **Used** |
|---|---|---|---|---|
| **Adaptation: Mitigation measures** | • Data classification (Ajmar et al., 2010) | | | |
| | -Baseline data layers (Ravan, 2010) | Space based information Technical Profile (S. Zlatanova, 2013) | Upon registration via Internet, Disaster Portals (S. Zlatanova, 2013) | Local and Regional Government (S. Zlatanova, 2013) |
| | -Utility and infrastructure data layers(Ravan, 2010) | | | |
| | -Disaster specific data layers (Ravan, 2010) | | | |
| | -Thematic data on terrain and natural resources (Ravan, 2010) | | | |
| | -Near-real time satellite data and thematic maps (Ravan, 2010) | International Charter "Space and Major Disasters: free images (Lewyckyj & Everaerts, 2005a), Space-based Information | GeoRSS Portals, Ad-hoc Web Application , UN agency field staff (Ajmar et al., 2011) | UN agency, Humanitarian Organization (Ajmar et al., 2011) |
| | • Data discovery (Ajmar et al., 2010) | | | |
| | -GIS based baseline and thematic spatial data (Ravan, 2010) | Government and Non-Government Organizations (NGOs) and International Agencies Ministry of Civil Affairs Information Centre (Cygan & Patterson, 2010) | Humanitarian Information Centre (HIC) set up by United Nations (UN) GIS Software-based Support System, Earthquake Portals (Cygan & Patterson, 2010) | Command Centres and out in the field, Humanitarian Community (Cygan & Patterson, 2010) |
| | -Baseline and thematic data integrated both centrally and risk related (Ravan, 2010) | | | |
| | • Data sharing (Ravan, 2010) | | | |
| | -Adopt Spatial data infrastructure (Ravan, 2010) | Data and Software Suppliers, Scientific Institutions (Koehler, 2005) | Networks of Administrative Players (Koehler, 2005) | Special Interest Group: National Geo-information and Disaster Management Organization, Users of Geographic Information (Koehler, 2005) |

| | | | | |
|---|---|---|---|---|
| | - SDI framework (Ravan, 2010) | Administration, Industry, Science and Citizens (Koehler, 2005) | Open Geoinformation "Geo-information Market" (Koehler, 2005) | All levels of Government, Commercial sector, Non-Profit sector, Academia and Citizens (Koehler, 2005) |
| | -Spatial data integrated with space-based information (Ravan, 2010) Spatial data serving post-disaster activities | UN platform for Space based Information for Disaster Management and Emergency Response (UN-SPIDER) (Ravan, 2010) | Geo-information Technology Community (Lemmens, 2005), Web map servers (Ravan, 2010) | National Governments (Ravan, 2010), Regional and Local Government Prevention activities (J. Li et al., 2005. ), Disaster Management Organizations (Ravan, 2010) |
| | -Enterprise GIS (Ravan, 2010) | University GeoICT Lab (Abdalla & Tao, 2005) | National Geological Survey Department (Abdalla & Tao, 2005) | Community Policy makers and Planners (Castle & Longley, 2005), Disaster Management Offices |
| | - Web mapping services (Ravan, 2010) | Researchers (Gogu, Freimark, Stern, & Hurni, 2005), Geospatial Databases (Ravan, 2010) | Web Map Servers Web Standard (WMS) (Ravan, 2010) | National Organization: Planning and Decision Making (Gogu et al., 2005) |
| | • Compilation of an inventory of space resources (S. Li et al., 2010) | | | |
| | -Space-based Information | United Nations General Assembly (Backhaus et al., 2010) | The United Nations Platform for Space-based Information for Disaster Management and Emergency Response (UN-SPIDER): Global Network of Regional Support Offices and National Focal Points (Backhaus et al., 2010) | Institutions, Practitioners (Backhaus et al., 2010) |
| | • Scientifically based effective emergency operational procedure (S. Li et al., 2010) | | | |
| | -Scientific information | Technological Institutions | Open Systems | Humanitarian Organizations |
| | • Mobilizing social resources (S. Li et al., 2010) | | | |

| | | | | |
|---|---|---|---|---|
| | -Social Resource | Community Organization | Census Data Management Agencies | National Government, Disaster Management Database |
| | • Integration of images with social information, statistical disaster information and field investigation (S. Li et al., 2010) | | | |
| | -Geo-Portals | Non-Government Organizations, Community Organizations | Web services (OpenWeb Services (OWS)) | Local and Regional Government (S. Zlatanova, 2013), Humanitarian Organizations |

## 3.4. Products and Services used in Haiti (2010) and Wenchaun (2008) Earthquake

### 3.4.1. Haiti (2010) Earthquake

The geo-information need in the Haitian Earthquake was entirely for Post-earthquake damage assessment. It focussed on large circulation of information and emergency management for the formation of Rapid Impact Analysis maps (Ajmar et al., 2011). Digital helicopters with virtual pilots working for free has started since 2010 Haiti Earthquake by the Digital Humanitarians for the response activities. However the maps can be refined and improved as the process is not considered a perfect one (Meier, 2014b).

Figure 11 Geo-Eye image shows Port-au-Prince, Haiti after a 7.0-magnitude earthquake struck the area on Jan. 12, 2010. The image clearly shows extensive damage, roads covered with debris from collapsed structures, and people crowded in the streets and public places such as sports fields and stadiums. The image was taken by the GeoEye-1 satellite from 423 miles in space at 10:27 a.m. EST on Jan. 13, 2010

(Source: www.geoeye.com/CorpSite/gallery/detail.aspx?iid=287&gid=1)

Earthquake in Haiti 2010 is one of the highly devastating catastrophes that it has experienced. This might be due the nature of the hazard itself or even strengthened by the

country's inability to sustain such a catastrophe in its current status regarding DRM efforts and execution activities. These are natural hazards which are not initiated by the people but propagate according to the level of risk it has on the people. This is basically done by bringing proper management measures ahead in time. DRM is one of those measures that have to be dealt thoroughly addressing the cycle of disaster risk management and activities of community to achieve the level of resilience accustomed to the context (Sheridan, 2010).

The findings on physical damage and economic losses were done through Post Disaster Needs Assessment (PDNA). The satellite and high resolution aerial imagery was used for damage assessment during the initial days of earthquake. Optical and radar data was rapidly acquired for the whole country through the space and funding agencies, the providers of satellite/aerial data. DigitalGlobe initiatives acquired optical satellite data and World Bank-ImageCat-RIT acquired aerial imagery including in addition, both thermal and lidar. It produced to provide effective information to the humanitarian organization. The initial damage assessment provision for different initiatives of emergency response stage primarily focussed on the humanitarian assistance contrary to Search and Rescue (SAR) operations, the reestablishment of the main logistic routes, the management sharing and coordination of information and the initial damage and need assessment. PDNA framework consists of Detailed Damage Assessment which however could not be produced due to time constraints and the reason that it is performed in Recovery Stage. Initial Damage Assessment was done to provide resources by optimizing and allocating them as per time constraints and to provide effective products and services. The geo-referenced data and the outputs from Initial Damage Assessment were the needs of the end user, United Nations World Food Programme (UN WFP). The information on the location of the most affected areas and road accessibility were requirements for WFP. (Ajmar et al., 2011).

Figure 12 Geo-Eye image shows Port-au-Prince, Haiti after a 7.0-magnitude earthquake struck the area on Jan. 12, 2010

(Source: http://www.geoeye.com/CorpSite/gallery/detail.aspx?iid=287&gid=1)

Initially, a GeoEye-1 satellite high resolution imagery (resampled to 50 cm) for commercial use was acquired. A stereo imagery was acquired which was made accessible by Google through Google earth/ Map overcoming the issues of licensing to assist rapid disaster response needs. In addition, Google made an immediate dissemination of data through a downloadable a collection of approximately 15 cm resolution imagery as base layers (Ajmar et al., 2011).

Web Services compliant with OGC was arranged to enable the specialists of GIS to work in their own environment and to avoid downloading. The end user's need to acquire data of inaccessible or restricted roads, spontaneously gathered camps, either collapsed or damaged buildings and affected logistic network were done by making use of high resolution data though remote sensing technology. A crew of volunteers were involved for manual data interpretation due to time constraint and the absence of rapid and automatic data interpretation for post-earthquake damage assessment. Multi-temporal comparison was made for analysis purpose. Simple but standard rules for image interpretation and grid approach were adopted on the area covered by satellite imagery. Alongside, participatory approach was applied to map a large area of Haiti since information was important compared to accurate information at the initial post-earthquake days. These maps and data were disseminated through email attachments, web pages as well as GeoRSS portals. Raw data was made available in an ad-hoc web application for displaying, querying and editing purpose specifically for the GIS specialists (Ajmar et al., 2011).

Spatial Data Infrastructure (SDI) on World Food Programme (WFP) contains the cartographic products, the reference datasets with worldwide coverage fulfilling the need of disaster in a critical case of a developing country like Haiti. The maps enabled the staffs of WFP to reach the camps of displaced people though the passable roads and for the formation of distribution sites. The maps from WFP which is disseminated widely has become the operational standard for emergencies (Ajmar et al., 2011).

Web-based mapping services such as CrisisCamp Haiti, OpenStreetMap, Ushahidi and GeoCommons were used to offer individuals with the ability to offer the relief and aid agencies without their physical presence in Haiti. It is a form of crowd sourced online mapping volunteered geographic information (Zook, Graham, Shelton, & Gorman, 2010).

Information and communication technology development through GPS, Web 2.0 and mobile phones in Haiti earthquake has made successful efforts to produce maps of affected areas of natural disasters through collaboration with civil society (Manfré et al., 2012).

### 3.4.2. Wenchaun (2008) Earthquake

A large number of people were mobilized to minimize the losses of lives by organizing the fastest quake relief effort. Emergency response was in accordance with the National Disaster Relief Contingency Plan. The emergency space technology support operations provided the technical support and information on national disaster relief to the decision making support agency for national disaster management (NDRCC). The international and domestic data providers were requested by NDRCC for EO images within two hours of earthquake. International Charter "Space and major Disasters" were sent the requests for international data acquisition.

Similarly institutions and agencies owning satellite images regarding domestic acquisition were sent requests

Figure 13 Unmanned airplane image of Wenchaun County (Yingxiu town), Sichuan Province, 14th May 2008, NDRCC (S. Li, Fan, Yang, & Wang, 2010)

by fax and phone. The interesting thing about this case is the management of image acquisition. In the first 24 hours, 2 images were acquired followed by a total of 1257 images from 24 satellites and 12 countries where 622 were archived ones, 635 were newly acquired ones and 138 made provision through International Charter "Space and Major Disasters". In addition, more than domestic agencies provided images free of charge. The integration of airborne remote sensing images, field survey and disaster statistics was done. The State Bureau of Surveying and Mapping of China (SBSM) and Chinese Academy of Sciences acquired the earthquake affected airborne remote sensing images. Similarly, NDRCC obtained the unmanned airborne remote sensing images. The field teams acquired field investigation information and through the local government the daily statistic disaster information data in the county level is acquired.

NDRCC, a comprehensive spatial database for information extraction and applications is uploaded with preparation data for disaster assessment such as background data including geographic data, social statistical data spatially integrated and earthquake affected area imagery. Preliminary details about loss of lives and property is assessed through pre-assessment maps based in background data. It is useful to the decision makers prior to the observation of acquired images. Image indexing is done for quick search of the gathered image of specific satellite name, sensor name, spatial resolution and time of observation. Data pre-processing was done for guaranteeing the consistency of optical and radar images and image extraction process was carried out in its second level image product. The information extraction from the prepared data gave information on collapsed houses, destroyed roads, distribution of evacuation routes and other disaster information such as changes in features using techniques such as information enhancement and change detection. Information extraction was made through high spatial resolution images for extraction of objects at less than 5 m. As necessity during disaster emergency rescue and relief, a general loss assessment was produced by emergency assessment map integrating remote sensing images, background data of the county level along with its disaster information data. The state councils used the damage map displaying the different levels of integrated assessment of affected people and damaged houses during reconstruction and recovery planning (S. Li et al., 2010).

Standardized template based mapping was applied in map products for quick map making loading extracted information and the results of assessments. More than a hundred of map products and services produced during the earthquake emergency relief were disseminated to four different agencies. Different forms of information media were used such as fax, email, news conference, hardcopy and website (S. Li et al., 2010). "The first and primary agencies were the central government emergency management agencies to support the emergency rescue, relief, recovery and reconstruction decision making. The second agencies were local government and field teams to support their field deployment. The third agencies were the public and international societies, to support their awareness raising and assistance. The fourth agencies were the professional institutions in support of their scientific research (S. Li et al., 2010)"

Provision and accessibility of effective and timely information and supporting activities during the emergency response management was the result of space technology. The working procedures of national emergency response had an important component with compilation of an inventory for the space resources. Timely acquisitions were ensured with the advantage of scheduled international and domestic space data acquisitions. A large number of space borne EO images of multiple types were acquired. The development of procedures for emergency operations were scientifically based and in accordance with disaster response requirements and space resources. Distinct responsibilities were assigned to different working teams formed for an effective working procedure. The social resources were mobilized and effectively used. Professionals from research institutes and universities exceeding 40 were mobilized as volunteers and participated in data processing and mapping activities. Remote sensing was not used alone for provision of information for disaster management but was essentially integrated with images interpreting social information, statistical disaster information and field investigation(S. Li et al., 2010).

However there was no dynamically planned observation time and location of the requested EO data for coverage over the entire area affected by disaster. The absence of observation plan brought a redundancy

among the images acquired focusing more on the epicenter which led to image shortage on the periphery of the affected area. The disaster management on emergency response could be improved by enforcing the capability for extracting useful information by processing massive amount of EO data. Data processing can be enhanced by developing automatic or semi-automatic methods enabling their implementation after 1-2 hours of acquisition (D. Li & Shao, 2009).

## 3.5. Conclusion

The chapter gives an example of the existing framework containing the products and services that can be exercised among the various institutions in the form of production, making their access and as end users. It gives an impression of the status of Disaster Risk Management and geo-information use. The framework is however analyzed in the following chapter giving emphasis on the resilience and community aspect of the framework.

# 4. FIELD WORK PROCESS

This chapter explains the methodological considerations of the research. It gives an overview of the case study area, sampling strategy applied for selecting the respondents followed by an overview on three phases of fieldwork; pre-fieldwork fieldwork and post fieldwork and the methods applied for collecting primary and secondary data. The list of geo-information related data that were collected during fieldwork is provided in this chapter.

## 4.1. Site Selection

Nepal experiences earthquake as a major disaster as it falls under the seismically active zone. The recorded earthquakes are from 1255 and the reason being the subduction of Indian plate under Tibetan plate. The major earthquakes recorded are 1408, 1681, 1810, 1833, 1866, 1934, 1980, 1988 and 2011 AD.

Table 6 Earthquakes in Nepal

| Year | Magnitude | Loss of lives | Loss of property |
|---|---|---|---|
| 1934A.D. | 8.4 Richter scale | 16,875 people | 3,18,139 houses |
| 1980 A.D | 6.5 Richter scale | 178 people | 40 thousand houses |
| 1988 A.D. | 6.6 Richter scale | 721 people, 1566 cattle heads | 64,467 houses |
| September 18, 2011 A.D. | 6.8 Richter scale | 6 people | 68 houses (completely) |

These facts suggest that Nepal is a disaster prone country facing earthquake as the most devastating disaster (S. M. Shrestha, 2012). After the most devastating earthquake in 1934, the next major earthquake can strike anytime with a magnitude of 7.5 to 8 with a frequency of occurrence in every 80 years. It is therefore a fact that a mega-quake is imminent in Nepal. According to NSET such mega-earthquake according to 1998 data can have estimated deaths of 40,000, injuries of 95,000 and buildings and collapse of 60 percent of houses. However, in today's context, it is reported to have 2.5 times more deaths and injuries. The crowded urban areas are the high-risk places being typically vulnerable. The JICA Report of 2002 shows that Kathmandu maybe unable to function as a capital city of Nepal.

The major reasons are the present status of disaster management system in Nepal being in the process of formulation. Other reason is the lack of sufficient awareness and knowledge of preparedness and mitigation measures among the general public. This requires an extra effort from Nepal itself in order to improve the present situation of disaster risk management particularly in preparedness and mitigation phases. Nepal needs to be prepared with proper plans though the frequency of earthquakes is low. Preparedness and mitigation are highly important and should be established at all levels of Nepalese society. The vulnerability of earthquake is prominent in the crowded urban areas of Kathmandu valley (GoN, 2002-2013). There are serious implications of urbanization lacking infrastructure facilities such as very poor resource base. It is caused by the coupling of unprecedented population growth, internal migration and unplanned activities of development (Karna, Mandal, & Bhardwaj, 2013).

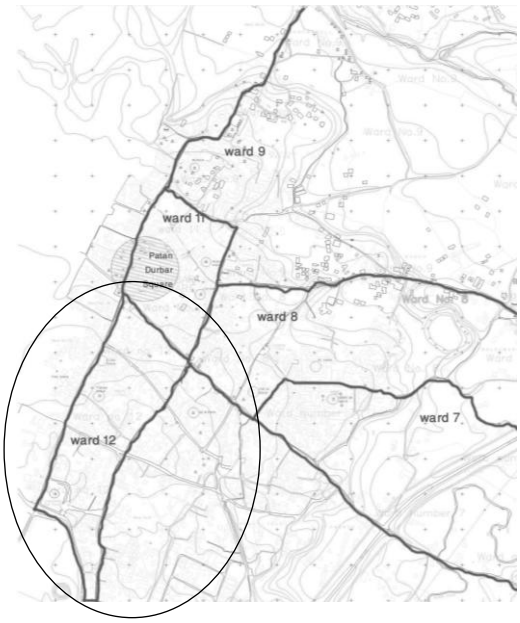



Figure 14 Selected area for case study

The process of site selection is carried out referring to evaluation of community resilience with the focus on geo-information towards earthquake disaster. In order to have a sizable case study area, among the 22 wards of Patan, Lalitpur, ward no. 12 was selected. The study area falls in Lalitpur district. Lalitpur district contains one sub-metropolitan city, under which the Patan city is situated, and 42 Village development committees. The name of the sub-metropolitan city is Lalitpur Sub-metropolitan City (LSMC). The total population LSMC is 162,997 with 84,208 males and 78,789 females in 35,000 households according to Central Bureau of Statistics of Government of Nepal (2001). The site area is adjoining the Patan Durbar square which is one of the monument zones of the Kathmandu world Heritage site. It is basically a residential area but it houses some of the ancient and medieval monuments such as the Mani Hiti, the stone tap built in the sixth century to the Matsyndra Nath Temple built in the seventeenth century. It has Hindu as well as the Buddhist religious monuments (Marahatta, 2011).

The research aims to evaluate on the social aspect and a community environment with traditional settings has become the choice of site selection. The selection of the site is due to its belonging to an ancient settlement and is a core area Patan. The locality is physically and socio-culturally bounded by recorded history also available in the literature of seventeenth century on Patan. It is a very old locality having bonding and ties with the informal community based organization such as trust *(guthi)*. *Guthi* are the traditional institution in Nepal which has a continuing history spanning over 1500 years.

The second reason for the site selection is the presence of the Local Disaster Risk Management Committee (LDRMC). The LDRMC under the ward office is supported by NGOs for earthquake related awareness and trainings. They are Nepal Red Cross Society (NRCS) presently supporting the site and Nepal Society for Earthquake Technology (NSET) who have been working in the past. They work extensively in the sector of earthquake disaster risk management. The selected site has strong social ties along with earthquake information. Thus it is an interesting study area to wee whether access to geo-information could contribute to analysing community resilience.

The following table shows the household distribution of the selected municipal ward and corresponding traditional communities (toles):

Table 7 Ward, Research Population and Sample Households

| Ward # | Number of households | Name of toles (communities/neighborhood) | Sample household population * |
|---|---|---|---|
| 12 | 1129 | Chabahal, Chakrabahil, Chochhen, Ha:kha, Mangalbazzar | 114 |

## 4.2. Pre-Fieldwork

The following activities were done for the preparation for field work and data collection:

- **Carrying out literature study**

Literature study on the research area was done to form the framework of community resilience.

- **Designing Questionnaire for data collection**

The questionnaires are designed for data collection. It is limited to the framework of community resilience. Some questions are about basic information and others are developed to assess

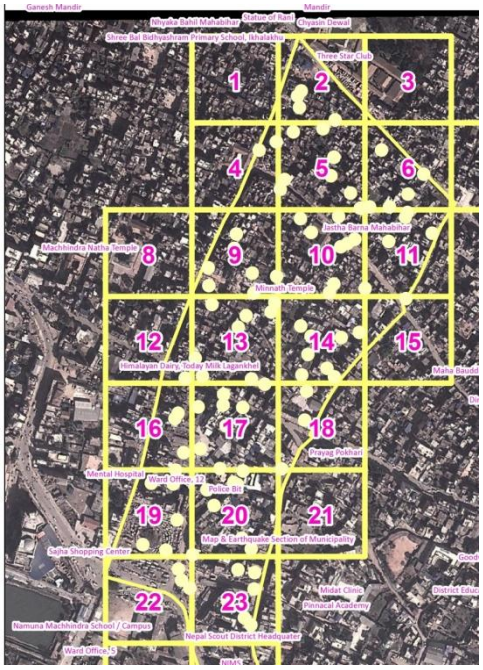


Figure 15 Case study area with sample point

the non-spatial and spatial information such as geo-information of earthquake disaster.

- **Developing field work schedules**

A large amount of data had to be collected in a very short span of time. Therefore, the schedules regarding field work were developed beforehand.

- **Calculating number of samples**

A google map is used and shape file of ward no. 12 boundary along with few renowned place names are overlaid. A grid of 100m x100m is placed on the map forming a total of 26 square grids (shapes) and 10 maps. The strategic sampling is done by generating random points using spatialecology.com. The points are generated on the basis of the size of these 26 irregular in shapes. The maps are printed in colour and are in the scale of 1:1000.

- **Fixing stakeholder appointments**

The interview was taken with the officers of respective institutions. It was ensured that the officials in charge who are involved with the disaster risk reduction wing of the institute were involved in the interview.

Table 8 Institutions selected for interviews

| S.N. | Name of Organization | Type of Organization | Purpose |
|---|---|---|---|
| 1. | Ministry of Home Affairs (MoHA) | Central Government/ Ministry (Organization) | Umbrella Agency for Disaster Risk Reduction in Nepal |
| 2. | Ministry of Federal and Local Development (MoFALD) | Central Government/ Ministry (Organization) | Works in Preparedness Sector in Local Level |
| | Survey Department | | |
| 3. | Department of Urban Development and Building Construction (DUDBC) | Ministry (Organization) | Strong in Reconstruction and Rehabilitation and also for building triage after the earthquake |
| 4. | Lalitpur Metropolitan City | Government structure Municipality | Local Government |
| 5. | International Centre for Integrated Development (ICIMOD) | INGO (Organization) | Strong in mountains related disasters and very relevant because Nepal consists of some of the tallest mountains of the world |
| 6. | United Nations Development Programme (UNDP) | UN (Sector) | Initiated disaster risk reduction efforts in Nepal |
| 7. | World Bank | DONOR (Sector) | Supports disaster related projects |
| 8. | Mercy Corps | INGO (Sector) | Works on community based disaster projects in Nepal |
| 9. | Save the Children | INGO (Sector) | Works for the support of children after disasters |
| 10. | Practical Action | INGO (Sector) | Works on early warning system in particular |
| 11. | Disaster Preparedness Network (DPNeT-Nepal) | National Network organization | Network organization of all international and national organizations |
| 12. | Nepal Red Cross Society | NGO (Organization) | Established in all 75 districts of Nepal and very extensively working in disaster sector |
| 13. | Nepal Center for | NGO (Organization) | Worked on disaster risk reduction in software such |

| | | | |
|---|---|---|---|
| | Disaster Management (NCDM) | | as legal aspects and hardware such as development of technologies for disaster risk reduction |
| 14. | National Society for Earthquake Technology (NSET) | NGO (Organization) | Worked extensively in Disaster Risk Reduction since a very long time with focus in earthquake disaster |
| 15. | CORD | NGO (Organization) | Emerging recent disaster risk reduction consultant |
| 16. | Ward | (Neighborhood/ Community) | Smallest Political unit |
| 17. | *Guthi* | (Trust group/ Community) | Cultural institution whose history goes back to 1500 years old institution |

- **Deciding on sample methods for selecting sample units**

A total of 115 households were selected for carrying out survey with structured questionnaires. The sample size is derived on the basis of population size (total households). 10% of total households are taken for sampling, which is a rule of thumb in case of survey, from a total of 1129 households which is 113 households. It was rounded up to 115 households. The survey of 99 random households was done by stratified random sampling. In addition 14 households were selected for snowball sampling by using the same questionnaires. This was selected on the basis of households/ individuals having had training given by the NGOs and INGOs such as NSET and Red Cross while the earlier households were recruited on the basis of no such grounds.

- **Formulating data collection lists**

The list of data collection was formulated such as non-spatial and spatial primary and secondary data.

- **List of geo-information products and services**

A number of government, non-government, humanitarian and community agencies, organizations and individuals are studied to list their geo-information products and services. They are as follows.

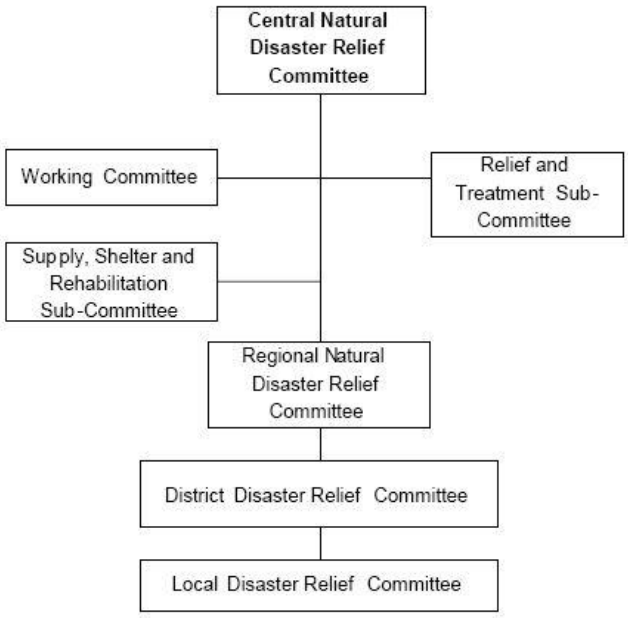



Figure 16 Disaster Management in Nepal (Source: Nepalese Journal on Geoinformatics- 11, 2012)

Table 9 List of geo-information products and services within various levels of institutions

| S.N | Name of Organization | Geo-information Products ( Maps and Data) | Geo-information Services |
|---|---|---|---|
| | Ministry of Home Affairs (MoHA) | Nepal Disaster Report, 2013<br>Nepal Disaster Report, 2009<br>National Strategy for Disaster Risk Management, 2009<br>Guidance Note Disaster Preparedness and Response Planning 2011<br>Code of Conduct (MoHA, 2014b) | National Emergency Operation Centre<br>District Administration Offices<br>Police Record Management Department<br>National ID Management Centre<br>Department of Prison Management<br>Department of Immigration<br>Armed Police Force<br>Nepal Police (MoHA, 2014a) |
| | Ministry of Federal and Local Development (MoFALD) | GIS Map of 75 Districts<br>Kathmandu, Lalitpur and Bhaktapur: Administrative Boundary, Land Utilization, River, Road Network (Appendix-5) (GoN, 2013b) | District Development Committees (DDC)<br>Municipalities<br>Village Development Committees (VDC)<br>Municipal Management Division: Disaster Management and Municipal Planning Section (GoN, 2014b) |
| | Ministry of Land Reform and Management<br>(Survey Department) | Geodetic Control data<br>Aerial Photographs<br>Topographic Base Maps:<br>Terai and middle mountain at the scale of 1:25,000<br>High hills and Himalayas at the scale of 1:50,000<br>Land Resources Maps<br>Administrative and Physiographic Maps of Nepal<br>Maps of Village Development Committees/Municipalities<br>District, Zone and Development Region<br>Digital Topographic Data at scales 1:25,000 & 1:50,000<br>Digital Topographic Data Layers: Administrative, Transportation, Building, Land cover, Hydrographic, Contour Utility (Nepalese Journal on Geoinformatics -12, 2070)<br>Cadastral Plans<br>Orthophoto Maps<br>Orthophoto Digital Data (Image)<br>Sub urban and core urban areas at scales 1:10 000 and 1:5 000 using aerial potography of 1:50 000 and 1:15 000 scales (Nepalese Journal on | Establishment of control points for various purposes of Surveying and Mapping<br>Cadastral Surveying<br>Photo Laboratory Services<br>Surveying and mapping for development activities<br>Topographic and large scale mapping<br>Digital geo-spatial database support<br>GIS Development |

| | | | |
|---|---|---|---|
| | | Geoinformatics -12, 2070)<br>SOTER Data<br>VDC Maps (Colour)<br>Topographic Digital Data at scales 1:100,000 1:250,000 1:500,000 1:1,000,000 (GoN, 2012c) | |
| | Department of Urban Development and Building Construction (DUDBC) | Digital Base Maps of Kathmandu Valley 16 Municipalities in joint collaboration with the concern municipality and donor agencies (GoN, 2013a) | National Building Codes<br>Earthquake Risk Reduction and Recovery Preparedness Programme for Nepal |
| | National Society for Earthquake Technology (NSET) | Seismic Zoning of Nepal (refer: Appendix 9)<br>Earthquake Hazard Map of Nepal (500 Year return Period Contours of Peak Ground Acceleration on Subsoil Type 2) (refer: Appendix 10)<br>Earthquake Intensity Map of 1934 Earthquake in Kathmandu Valley (refer: Appendix 11)<br>Liquefaction Susceptibility Map of Kathmandu Valley (refer: Appendix 12)<br>Identified Open Spaces in Kathmandu Valley (refer: Appendix 13)<br>Identified Open Spaces (Lalitpur Sub-Metropolitan City) (refer: Appendix 14)<br>Identified Potential Evacuation Sites (Lalitpur Sub-Metropolitan City) (refer: Appendix 15)<br>Population Holding Capacity of Identified Open Spaces in Kathmandu Valley (refer: Appendix 16)<br>Size of Identified Open Spaces in Kathmandu Valley (refer: Appendix 17)<br>Usable area of Identified Open Spaces in Kathmandu Valley (refer: Appendix 18)<br>Identified Open Spaces in Kathmandu Valley (Usable area of the open spaces)<br>Identified Open Spaces by Ownership<br>Potential Ground Water Yield Zoning (Lalitpur Sub-Metropolitan City) (refer: Appendix 19)<br>Existing Deep Tube Wells (Lalitpur Sub-Metropolitan City) (refer: Appendix 20)<br>Existing Deep Tube Wells Selected for Detailed Assessment (Lalitpur Sub-Metropolitan City)<br>Distance between Recommended Deep Tube Wells and the Proposed Evacuation Sites (Lalitpur Sub-Metropolitan City) (refer: Appendix 21)<br>Building Age of the Urban Regeneration Pilot Site (Kathmandu Metropolitan City, Ward No. 21 &23) (refer: | Analysis and management of GIS data/information<br>Disaster information management for previous years using DesInventar System<br>Integration/managing of GIS data<br>Spatial analysis<br>Production of maps<br>Risk assessments maps Hazard identification maps Awareness<br>Teaching<br>Policy advocacy<br>Local level disaster management planning (ward/VDC/Municiaplity level) |

| | | | |
|---|---|---|---|
| | | Appendix 22)<br>Ghorahi Municipality (South ghorahi Earthquake Scenario, Mg. 7.2.) (refer: Appendix 23)<br>Existing Water Supply System (Preliminary Results) (refer: Appendix 24)<br>Mapping of VDC, Nepal (Appendix 25)<br>CBDRR in Kathmandu District Chapter (refer: Appendix 26)<br>CBDRR Program Implementing VDCs and Wards in Kathmandu Valley (refer: Appendix 27)<br>School Earthquake Safety Program in Kathmandu Valley (refer: Appendix 28) | |
| | Flagship 4 (Community Based Disaster Risk Reduction) | Information Platform for exchange of information on CBDRR in Nepal<br>Identify hazard prone districts using secondary data (Flagship, 2013) | Completion of 1,000 CBDRR activities at VDC/municipality level |
| | Kathmandu Living lab | OpenStreetMaps (refer: Appendix 29) | |
| | International Centre for Integrated Development (ICIMOD) | Geo-visualisation platform for Kathmandu valley for emergency response in the case of earthquake disasters (GeoMountain, GeoPortal for Earthquake Emergency Management and Response System for Kathmandu Valley)<br><br>Network analysis tools for identifying nearest facilities and routing during the emergency situations (ICIMOD, 2014) | GeoPortal for Emergency response (ICIMOD, 2014) |
| | United Nations Development Programme (UNDP) | National Strategy for Disaster Risk Management<br>Disaster Risk Reduction in Nepal (DRRN) Project<br>Comparative Disaster Risk Management Programme<br>Earthquake Risk Recovery Programme (ERRP) (UNDP, 2012 -b) | Establish National Emergency Operation Centre<br>Establish 11 District Emergency Operations Centres (UNDP, 2012 -b)<br><br>VDCs (Village Development Committees) received support to become disaster resilient<br>Over 2000 community volunteers trained on community disaster risk (UNDP, 2012 -a) |
| | World Bank | Climate Change Knowledge Portal (Bank, 2014d)<br>Earthquake Mortality Risk Map (Bank, 2014b) | Climate Adaptation Profile (Bank, 2014a) |
| | Practical Action | Climatic maps: Temporal and spatial variations (precipitation and temperature)<br>Climatic Map of Ecological zones | Formation of different national forums<br>Advocate policy change<br>Increase the impact of its |

| | | | |
|---|---|---|---|
| | | Climatic Map of Whole Nepal | operational work (Action, 2014b) |
| | Disaster Preparedness Network (DPNeT-Nepal) | Facilitator to Disaster Preparedness activities to institutions involved | |
| | Nepal Red Cross Society (NRCS) | Network of Red Cross workers throughout the country (NRCS, 2009 -a) | Disaster Impact Reduction (NRCS, 2009 -b) |
| | Lalitpur Municipality | • Technical and Financial support<br>• Capacity development programmes<br>• Coordination with local bodies<br>• Disaster risk management programmes<br>Registration of Community Disaster Management Committee<br>Formulation and Implementation of Disaster Risk Management Plans and their coordination to different level of institutions (GoN, 2011) | |
| | Ward (LDRMC) | Formulate, implement and monitor Disaster Management Plans of Municipality and VDC<br>Support District Disaster Management Committee<br>Arrange Trainings and instructions on disaster<br>Support community disaster management committees in registration with municipality or VDC etc. (GoN, 2011) | |
| | *Guthi* | Religious *Guthi*<br>Service-oriented *Guthi*<br>Communal *Guthi*<br>Entertainment-oriented *Guthi*. (S. Shrestha, 2010) | |

### 4.3. Fieldwork

The following activities were carried out during the field work and data collection:

- **Carrying out training to the enumerators**

7 Students of bachelor in social sciences conducted the random household and trained individual level surveys. The reason for choosing these enumerators is because of their social background and their knowledge on survey. They were trained for a day and made familiar with the context. The enumerators were specially instructed to ensure that nothing is missing in the questionnaire. (refer: Appendix. 4 for picture of enumerators getting training on conduction of survey)

- **Testing questionnaire**

A pilot random household survey was conducted to test the best fit of the questionnaire. The questions were modified after a pilot survey. It was corrected and sent out for the remaining surveys.

- **Filling of questionnaires**

They worked for 15 days in the site and collected information of 99 random households and 15 trained individuals. He research has adopted two types of questionnaires:

**i. Semi-structured questionnaires**

The experts are interviewed with unstructured questionnaires. The reason is that a lot of other important information can be derived and discussed from it.

**ii. Structured questionnaires**

The random households and trained individuals are interviewed with structured questionnaires. The main purpose is to have a statistical analysis.

- **Collection of primary data**

The field work was for 23 days. Interviews with a number of institutions ranging from the national, local and community level were carried out. In most of the cases in household surveys, the adults are asked to take part.

The research has adopted three basic methods for primary data collection. They are as follows:

**i. Interviewing national, local, I/NGOs**

Expert interview were conducted to receive information from the central (MoHA, MoFALD), local (municipality), national and international organizations. They are asked about their roles and responsibilities in the existing organization in the context of flow of geo-information and non-spatial information on earthquake disaster. These include key informant, one-to-one interview. It is a closed type of interview.

**ii. Interviewing community based organization**

Expert interviews were conducted in community based organizations both formal (LDRMC) and informal *(guthi)* in the selected communities. The interview focussed on respondent's involvement in geo-information programmes and activities on earthquake disaster though such organizations. These also include key informant, one-to-one interview. However, it is an open type of interview.

**iii. Household and individual (trained) surveys**

Household interviews were conducted within 99 random samples. The interview focussed on the availability and accessibility of spatial and non-spatial information within them. They were randomly selected and therefore can be a mixture of trained an untrained households. Similarly, 15 trained individuals are interviewed with the same method. The only difference was that they were all trained on awareness raising programs from the formal community based organization (LDRMC).

A detail survey of the field is carried out to collect qualitative data. The primary observation and data collection is done during field work. Observations and photographic documents are also a part of it. Observation helps to gain a thorough understanding of the locality and its characteristics as a whole such as existing land use, physical, social, economic aspects assessment. Similarly, photographic documentation during observation helps to collect the pictorial evidence of the site and its milieu, the houses and the entities describing the status of the locality.

- **Collection of secondary data**

The relevant document and publication are reviewed which is an important methodological step of the study. The secondary sources of data, information are found basically through major documents like national profile, district profile, inventories, documents on DRM and policy, publications of CBS, topographic maps, earthquake hazard maps, land use map, topographic maps and image. In addition, documents related to the central and local government organizations, non-government organizations, private organizations, communities and trusts such as the reports of MoHA, DUDBC, NSET, UN, consultants etc. were reviewed. For identification and analysis purpose, software like Google Earth, GIS is also used. Non-spatial data in the form of reports were collected from all the institutes selected for interviews such as MoHA, MoFALD, UNDP, Municipality, *Guthi* etc. Spatial data and geo-information was collected from NSET.

## 4.4. Post Fieldwork

During the post-field work, data analysis, interpretation and results are compiled. The data collected is processed for analysis with the help of statistical analysis and discussion based on the indicators developed.

## 4.5. Constraints during field work and data collection

Some of the constraints during the fieldwork data collection are:

**i. Nature of disaster:** The specific nature of earthquake disaster is one of the constraints itself. Unlike the other disasters, in the aftermath of the earthquake the whole of the country or more than half of the country is likely to be affected. It is unlike other disasters like flood, fire or landslide when a particular district or a town is affected. In such a case, the other districts can come for the rescue. However in the case of a major earthquake the majority of the country's area is going to be hit. Therefore, there is no perception about it among the officials and the member of community. The information is based on the experience of isolated events like flood, landslide or fire and not as widespread disasters like earthquake. This was a big constraint.

**ii. Language:** The interviewees in the site area are from traditional Newar community. They communicate in Newari language which is not Nepali. This is mostly among the elderly and housewives. They have strong social and cultural ties and therefore are hesitant to give information to the outsiders of a different society and culture. In these cases, assistance is needed to get the right information.

**iv. Status of research related knowledge and activities:** The questionnaires derived from the framework are elaborate in the sense that much of the activities are not yet present in Nepal. To get interviewed for such questions is quite burdensome to the interviewees as they could not relate for instance.

## 4.6. Conclusion

The field data collected through the primary and secondary sources are used in the following chapters to understand the present status of Disaster Risk Management activities carried out by the institutions involved. The field data focuses on the geo-information availability among the institutions for making an analysis in the following chapter judging the differences with the framework developed in the previous chapter.

# 5. ANALYSIS AND RESULTS OF COMMUNITY RESILIENCE

In this chapter the Disaster Risk Management work conducted in Nepal is outlined. The focus is towards the resilience and community activities that have undergone in such institutions. Therefore in the case study, the collection of data from the study area focuses only the community sector. The framework and the lesson learned in the previous chapter serves to judge the difference and analyze the gap between the contemporary scenario of an ideal situation and the case study area indicating Nepal as a whole. Community Resilience is however not measured but the aspects that have created the gap are analyzed.

## 5.1. Review of Collected Data

Multiple sectors and disciplines are involved in an integrated and continuous process of Disaster Management for planning and implementation (Burzykowska, 2012). Therefore the analysis of community resilience is done by dividing the work carried out in each of the institutions related to DRM in Nepal. It is the outcome of the secondary data collection. The table below has the lists of work done and are placed among the most suitable indicators such as Social Capital, Social Resilience and Resilience. It is done to analyse the status of the involvement of the institutions regarding DRM in Nepal.

Table 10 Specific Review of DRR and Geo-information related activities for Community Resilience

| Institutions | Social Capital | Social Resilience | Resilience |
|---|---|---|---|
| Ministry of Home Affairs (MoHA) | National Strategy for Disaster Risk Management in Nepal (NSDRMN) (Flagship, 2013) | Hyogo Framework of Action (HFA) 2005-2015 and UN "Cluster approach" (Flagship, 2013) | Disaster Resilient Nepal (Flagship, 2013) |
| Ministry of Federal and Local Development (MoFALD) | Disaster management and Municipal Planning Section (GoN, 2014c) | Widespread network up to grass-root level (GoN, 2014a) | Focal organization for promoting local development and decentralization (GoN, 2014c) |
| Survey Department | Uniformity in the mapping procedures and coordination (GoN, 2012c) | Global Navigation Satellite System Technology and its Application (GoN, 2012a) | National Geographical Information System (NGIS) (GoN, 2012b) |
| Department of Urban Development and Building Construction (DUDBC) | Building Construction Guidelines (ERRRP, 2010) | National Building Code (NBC) (ERRRP, 2010) | Strengthen the legal framework for NBC (ERRRP, 2010) |
| National Society for Earthquake Technology- | Information dissemination & Knowledge Transfer, Advocacy & | NSET division: Urban Disaster Risk Management (UDRM)/ Geographical | Earthquake safe communities in Nepal by 2020 (NSET, 2012b) |

| | | | |
|---|---|---|---|
| Nepal (NSET) | Networking, and Establishment of Credible Institution & Resource Center (NSET, 2012a) | Information System (GIS) (NSET, 2012b) | |
| Community Based Disaster Risk Reduction | Access to Disaster Risk Reduction (DRR) information (NRRC, 2012 ) | Organisational base at Village Development Committee (VDC) / ward and community level (Flagship, 2013) | Community based early warning systems (NRRC, 2012) |
| Kathmandu Living lab OpenStreetMaps | "A community where technical specialists work with domain experts to deliver solutions of nation's everyday problems" (KLL, 2014) | "A connector That fosters new partnerships from their diverse global network of innovative thinkers and doers" (KLL, 2014) | "A champion of Open Data and Civic Technology that creates open data, open maps and open source applications leveraging emerging web and mobile technologies" (KLL, 2014) |
| International Centre for Integrated Development (ICIMOD) | Regional resource centre for geo-information and earth observation application (with a specific mountain focus) (ICIMOD, 2008 - 2014a) | Global innovations and regional socio-cultural context (ICIMOD, 2008 - 2014b) | Knowledge Management and Communication: An open house for knowledge initiatives (ICIMOD, 2008 - 2014b) |
| United Nations Development Programme (UNDP) | UNDP support focus on reducing disaster risks through policy and local community level efforts (UNDP, 2012 -b) | Comprehensive Disaster Risk Management Programme (UNDP, 2012 -a) | National Emergency Operations Centre (UNDP, 2012 -b) |
| World Bank | Building Resilience to Climate Related Hazards Project (Bank, 2013) | Modernization of the observation networks and forecasting (Bank, 2014 ) | Building Resilience to Climate Related Hazards for communities at risk (Bank, 2014c) |
| Practical Action | Development of Early Warning System (EWS) (Action, 2014a) | Mainstreaming DRR into development planning (Action, 2014a) | Building resilience for the earthquake vulnerable communities (Action, 2014a) |
| Disaster Preparedness Network (DPNeT-Nepal) | Promote and advocate principles, share experience and spread sustainable disaster management (DPNet, 2014) | Develop linkages and networks with similar institutions both nationally and internationally (DPNet, 2014) | Regular publishing of news, views and experience and their dissemination among the members of network (DPNet, 2014) |
| Nepal Red Cross Society (NRCS) | Largest humanitarian organization in Nepal (NRCS, 2009 -a) | Expanding and strengthening the organizational structure of the society (NRCS, 2009 -a) | Community Participation and volunteer mobilization (NRCS, 2009 -a) |
| Lalitpur Municipality | Disaster Preparedness and Response Plan Framework (DPRP) for an Emergency to a Major Earthquake | Formation of ward level disaster risk management committee (WDMC) (NSET, 2011a) | Community Based Disaster Management Program in Kathmandu Valley (NSET, 2011a) |

| | | | |
|---|---|---|---|
| | (NSET, 2011b) | | |
| Ward (LDRMC) | Ward Level Disaster Management Committees DMC (through Ward Assembly) | Disaster Management Training | Vulnerability and Capacity Assessment (VCA) |
| *Guthi* | Cultural tradition of the '*Guthi*': Crucial in developing, operating and sustaining | Community based organizations: *Guthi*s | *Guthi*: Flexible and accept change |

### 5.1.1. Institutions and the role of Geo-information in the Context of Community Resilience

#### 5.1.1.1. Analysis at Local Government level

- **Ministry of Home Affairs (MoHA)**

National Strategy for Disaster Risk Management in Nepal (NSDRMN) is a strategy. It improves the policy and legal setting. It prioritizes the strategic interventions. It has a standard use in DRM activities in Nepal. Social resilience is made through commitments in an international convention and forums such as the Hyogo Framework of Action (HFA) 2005-2015 and UN "Cluster approach". Such approach helps to achieve goals and create equivalent working groups for coordinating and communicating efforts. Cross-cutting issues are required to achieve this vision of "Disaster Resilient Nepal". As suggested by NSDRMN, the existing DRM structure requires an institutional mechanism that can fill in the gaps by such cross-cutting issues. These issues are however not open systems (Flagship, 2013).

- **Ministry of Federal and Local Development (MoFALD)**

It consists of Municipal Management Division looking after Disaster management together with Municipal Planning (GoN, 2014c). Among the few ministries of government MoFALD has a widened network reaching up to the grass-root levels from District Development Committees to Municipalities and up to Village Development Committees (GoN, 2014a). It also mobilizes the locally available resource through people's participation (GoN, 2014c). The approval of the guidelines of Local Disaster Risk Management Planning (LDRMP) was done by the Ministry of Federal Affairs and Local Development. It consists of description on the process for developing members of community consulted VDC/ municipality level disaster management plan. Such initiation however is challenging due to the fact that they include limited institutions involved in their development structure, insufficient resource and lacking disaster risk reduction trained personnel (Flagship, 2013).

- **Ministry of Land Reform and Management (Survey Department)**

The norms are provided through the mapping committee by a uniform mapping procedures. The trust is maintained by its ability to avoid duplication in mapping work for improving quality of finished product. Similarly, they have the environment to coordinate between different government organizations under difficult conditions (GoN, 2012c). GNSS technology promotion in its education and capacity building in applications of survey, mapping and Disaster Management and related applications. The technology is disseminated and applied to the decision makers, policy planners and professionals for fostering social resilience among them (GoN, 2012a). Department of Survey and the Central Bureau of Statistics along with more agencies are expected to prepare national geographical information infrastructure (NGII) by their participation. This will eventually cover all the agencies involved in production and use of geo-information and eventually operate National Geographical Information System (NGIS) in Nepal and aware data usage mechanism in various user organizations (GoN, 2012b).

- **Department of Urban Development and Building Construction (DUDBC)**

A nepali version of Building Construction Guidelines has been prepared by DUDBC. Similarly training activities are conducted among 500 mansons. DUDBC department works for the dissemination of National Building Code (NBC) throughout the nation. DUDBC department is works for strengthening the legal framework for NBC-Building Act 1998. They also work for the municipalities as guidance for the implementation of NBC (ERRRP, 2010).

#### 5.1.1.2. Analysis at Local Government level

- **Lalitpur Municipality**

Lalitpur Municipality has a Disaster Unit and is working with a major focus on Disaster Preparedness and Response. The DPRP is formulated and has been convincing the representations from the field to focus and apply on the framework. Lalitpur Sub Metropolitan City (LSMC) also focuses on preparedness for safe water through the framework during an earthquake disaster (NSET, 2011b). Ward level disaster risk management committees are formed in few of the wards of the Lalitpur Sub-Metropolitan City (NSET, 2011a). Community Based Disaster Management Program has been implemented in the WDMC for enabling them with the knowledge, awareness regarding disaster and the involvement of institutional organization (NSET, 2011a).

#### 5.1.1.3. Analysis at INGO level

- **World Bank**

World Bank enhances the capacity of government in mitigation of climate related hazards through weather forecasts and early warnings of flood for risky communities facing climate vulnerabilities. It also works for developing information system services for agricultural management and help farmers in mitigation activities (Bank, 2013). It works in the Strengthening of institutions and capacity development and their implementation in Department of Hydrology and Meteorology (DHM) aiming to develop its legal and regulatory frameworks as well as their institutional performance. It also ensures future network operability through capacity building of personnel and their management to support the implementation of project. Similarly it aims for bringing modern networking and forecasting for observation as well as enhanced system for service delivery of DHM such as public weather service forecasting weather and their impacts as well as information services for communities vulnerable to climate and the sectors involved in these aspects (Bank, 2014 ). They are involved in creating an Agriculture Management Information System (AMIS) at the Ministry of Agriculture Development (MoAD) (Bank, 2014c). Building resilience to climate related hazards can be achieved through establishing and enhancing capacities of multi-hazard information, early warning systems and by upgrading the existing hydro-meteorological system and agricultural management information system. The aspects such as decision-making and planning of water sources and climate vulnerability in various sectors including disaster management will be improved through the project. The contribution would be towards building climate resilience for communities at risk (Bank, 2013).

- **United Nations Development Programme (UNDP)**

UNDP established its Disaster Risk Reduction in Nepal (DRRN) project. It is continued by Comprehensive Disaster Risk Management Programme along with Earthquake Risk Recovery Programme (ERRP) focusing on policy and institutional strengthening referenced to the National Strategy for Disaster Risk Management (UNDP, 2012 -b). The programme is recommended by the national strategy for strengthening capabilities of disaster risk management through their application in government ministries and local bodies. Among others social inclusion and knowledge management are few aspects addressed in the project activities (UNDP, 2012 -a). UNDP established a National Emergency Operations Centre for the Ministry of Home Affairs through its Disaster Risk Reduction in Nepal (DRRN) project later continued by Comprehensive Disaster Risk Management Programme. 11 District Emergency Operations

Centres are established for coordinating and integrating DRR and in planning mechanisms (UNDP, 2012 - b).

- **Practical Action**

Practical Action's works in the Disaster Risk Reduction (DRR) is active towards building resilience through development of Early Warning System (EWS) in order to save lives, generate livelihoods and issues of men and women suffering vulnerability (Action, 2014a). The organization is working for strengthening the resilience of livelihood of the people by influencing the local governments and national stakeholders by mainstreaming DRR and adaptation to climate change into development planning and their institutional sustainability. It focuses on early warning for flood and landslides and building resilience for the earthquake vulnerable communities. They use community-based approach in line with the National Strategy for Disaster Risk Reduction (NSDRM) and aims for community capacity building to prepare and respond to disasters (Action, 2014a).

- **International Centre for Integrated Development (ICIMOD)**

The growth of ICIMOD's knowledge is from the capabilities of its thematic areas among which, one of them is Geospatial Solutions (ICIMOD, 2008 - 2014b). They use new technologies and customize them to geospatial science and make adaptations in its Thematic Areas based on situation specific to mountain (ICIMOD, 2008 - 2014a). ICIMOD has worked to breaking the barrier to development and research of the vast and remote areas of the Himalayas such as the Hindu Kush. It develops by institutionalizing remote sensing and geographic information systems. They support the development policies and give assistance at various levels through science-based decision making. ICIMOD fosters through the creation of new relations with the global innovations but remains relevant to the regional socio-cultural context. The knowledge sharing among them is though promotion of capacity development at various levels ranging from youths, partners, policy makers and decision makers. The purpose is to provide improved decision making and practical action by transformation of results of research into information. ICIMOD communicates the knowledge and information globally and online through publications, databases, multimedia, and web content serving as an open house for knowledge initiatives. It is looking forward into new communications and interactive knowledge sharing tools in future. They have become a global norm that provides improved efforts in knowledge management (ICIMOD, 2008 - 2014b).

#### 5.1.1.4. Analysis at NGO level

- **Disaster Preparedness Network (DPNeT-Nepal)**

DPNet-Nepal organizes symposia, conferences, workshops and meetings. They promote and advocate principles, share experience and spread sustainable disaster management. The focus of such activities is to link disaster management to development activities of the country. In order to bring synergy among the members of DPNet-Nepal, they organize training programs for skill and knowledge development among the people who provide training and those who practice it. Working for preparation and updating of a resource directory of the involved institutions and individuals whenever there is a need for assistance, support and provide suitable linkages to other institutions and the individuals involved in sustainable disaster management and development (DPNet, 2014).

- **Nepal Red Cross Society (NRCS)**

Nepal Red Cross Society (NRCS) being the largest humanitarian organization in the country has a wide network ranging from organizational support to District Chapters (DCs) from sub-chapters and co-operation committees working under them and extension to all 75 districts. Such networking activities are also represented by students and youth volunteers from schools, campuses and communities. NRCS is working for lessening vulnerability of humans by expanding and strengthening the organizational structure of the society by linking communities, governmental and non-governmental organizations. NRCS works through community participation and mobilizes volunteers and their increment focusing more on the democratic, transparent and participatory approach (NRCS, 2009 -a).

- **NSET**

One of the main strategies is to disseminate information and transfer knowledge through network of trusted agency involvement. Also dealing with advocacy with established credible institution and resource center (NSET, 2012a). The NSET consists of a Geographical Information System (GIS) division along with Urban Disaster Risk Management (UDRM) division which fosters new relations for communication of urban disaster geo-information related activities. NSET is established by the professionals in Nepal who are involved in earthquake disaster management in both technical and social aspects for obtaining a legal status (NSET, 2012b).

Figure 17 Community volunteers with NSET

#### 5.1.1.5. Analysis at Community level

- **Ward (LDRMC)**

The ward assembly is called for the formation of Ward Level Disaster Management Committees (DMC). They are called Local Disaster Risk Management Committees (LDRMC). Volunteers' participation from the various wards i.e. DMC is carried out to undergo Disaster Management Training. The volunteers participate in Vulnerability and Capacity Assessment (VCA) through trainings and workshops.

- **Community Based Disaster Risk Reduction**

It involves mechanisms for coordination and partnerships among the institution and agency. Their access to DRR information and involvement among governments at local, district and national levels, organizations in private, civil society sector as well as communities or groups in vulnerable situation and other key institutions possibly schools and hospitals for increment in social capital (NRRC, 2012 ) . As a priority objective of FLAGSHIP 4, Project Mapping of CBDRR/M activities is conducted in Nepal. Information on various aspects including geographical location is included for identifying the geographical gaps in CBDRR/M especially for information dissemination to the donors and partners involved in such DRR and management projects (Flagship, 2013). Flagship 4 in the minimum characteristics shows that early warning is a primary component for community resilience to disasters (NRRC, 2012 ). Community based early warning systems are inclusive and their integration with early warning systems of VDC/ward, district, regional and national levels are essential (NRRC, 2012).

- **Kathmandu Living Labs (OpenStreetMaps)**

Kathmandu Valley is in challenging phase both in urban development and provision of basic services. The valley has fragmented and overlapping jurisdictions and limited planning activities in transport and urban planning. The community has committed towards solving Nepal's demanding challenges by fostering through the power of collaboration activities. They are comprised of the local OpenStreetMap chapter, software start-ups, technical incubators and the relevant universities. Meetings and events are organized along with Mapping Parties for initiating network development. The technology community is active and growing to localize open government models that have gained success and civic innovations for improving the challenge of urbanization. Urban resilience and engagement of the civic innovations are enhanced through solutions based on internet and mobile technologies (KLL, 2014).

#### 5.1.1.6. Analysis at Informal Coomunity level

- ***Guthis***

*Guthis* have the culture and tradition to develop, operate and sustain the activities of their involvement in the religious, social and physical infrastructure of the town (Tiwari, 2002). *Guthi*s are Community based organizations but they are informal. Though they are of various types and work for the community movement, due to their unofficial tag, they remain informal. *Guthis* are flexible in the sense that they can

accept change. The flexibility can be seen in participating in cremation related activities as well as activities involving playing musical instruments and singing religious songs. These activities contrast each other.

#### 5.1.1.7. Analysis at Individual level

- **Individual**

The reason behind this is explained by the following figures, which shows the membership of the social institution among the households and trained individuals.

It is apparent from the above that maximum numbers of the people show their allegiance to informal community based organization or trust like traditional *guthi*. Tole Sudhar Samiti which has emerged recently and also recognized by the government has taken the second place. Households are traditional and it is natural that they will show their inclination to *guthi*. The trained individuals have shown their affiliation with the Womens' Group. It is followed by guthi. The preceding chart and this one shows the attraction for the *guthi* among the people showing its potential to act as an effective institution in the time of disasters. Even now *Si Guthi* is very active when the demises occur. *Guthi* appears as the first institution for the households and second among the trained individuals. In both the cases, it appears prominent. It is thus natural that it should be given preference for disaster risk reduction also as it has the potential to act as a viable institution.

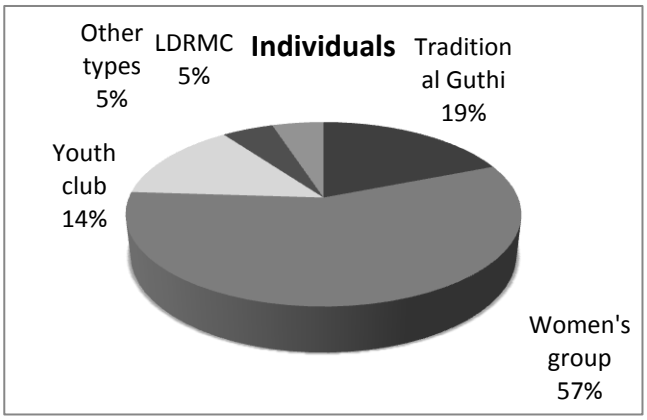



Figure 18 Percentage of trained individuals' membership in different social institutions

Both the figures indicate that individuals are influenced by the relatives who are the actual members in the *Guthi*. It indicates that the informal community of guthi should be empowered because the people are driven towards it due to its strong social tie. The result shows that specially the informal institution like *Guthi* displyayed strong potential for DRR.

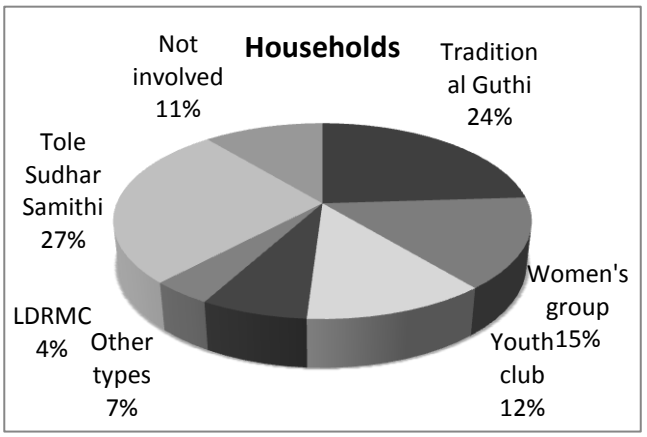



Figure 19 Percentage of households' membership in different social institutions

## 5.2. Overview of the types of Geo-information Produced, Shared and Used

In the preparation phase, the government organizations and Non-Government Organizations use the risk maps containing satellite images and LIDAR maps. They are produced by the International Charter Space, funding agencies, reseller companies and scientific information related institutions. Similarly spatial data from the satellite remote sensing are produced by the International Charter Space, funding agencies. Web services are used to share these information to Government organizations and Non-Government Organizations. Spatial Data Infrastructure Standards (SDI) are used by them through Web map servers. Such SDI frameworks are produced by the National Government and other agencies. Map based modelling is produced by the scientific institution and shared by the national Government and the disaster portals. The hazard maps are produced by the Local Government, Local Administrators and through community involvement and are accessed through NGOs, Social groups, Community groups for Government use. In coping phase, Government and Non-Government Organizations do manual interpretation for mapping involving large crew of volunteers through individuals and are accessed through National Government. In recovery phase, Government and Non-Government Organizations use the Volunteer Mapping produced by Mapping Community and Individuals made accessible through Web services such as OpenWeb Services (OWS). In adaptation phase, all levels of Government, Commercial sector, Non-Profit sector, Academia and Citizens use SDI framework which is produced by Administraion, Industry, Science and Citizens and made accessible by the Open Geoinformation "Geo-information Market".

## 5.3. Analysis at National Government level

In the preparation phase, the National Government uses the High Resolution Aerial Imagery for Topographic Mapping and Orthophoto data produced by Agencies for International Development ad accessed through National Coordinating Agency for Surveys and Mapping.

In adaptation phase, National Governments use Spatial data integrated with space-based information, spatial data serving post-disaster activities produced by UN-SPIDER and accessed by Geo-information Technology Community as well as Web map servers. National Organization are the end users of Web mapping services produced by the Researchers and Geospatial Databases which can be accessed through Web Map Servers Web Standard (WMS). The National Government, Disaster Management Database is the end user of the Social Resource developed by the Community Organization and accessed through Census Data Management Agencies.

In the case study, the National Government, Ministry of Home Affairs (MoHA) have prepared products such as National Disaster Reports, National Strategy for Disaster Risk Management, Guidance Notes and Code of Conducts. Their services are many, among which the earthquake disaster related are the formation of Nepal Emergency Operation Centre and Armed Police Force. They are working more on the policy level of Disasters, less on the Earthquake Disaster and therefore least on the geo-information aspects discussed above. Ministry of Federal and Local Development (MoFALD) have produced product such as the GIS Map of 75 Districts including the case study area Lalitpur. They contain the maps of Administrative Boundary, Land Utilization, River and Road. The services are on networking aspects. They have access of information from District Development Committees (DDC) to Municipalities to Village Development Committees (VDC) and to the Municipal Management Division: Disaster Management and Municipal Planning Section. However there is no mention of precise geo-information products and services. Ministry of Land Reform and Management (Survey Department)has products such as Geodetic Control data, Aerial Photographs, Topographic Base Maps, Land Resources Maps, Administrative and Physiographic Maps of Nepal, Maps of Village Development Committees/Municipalities District, Zone and Development Region Digital Topographic Data, Digital Topographic Data Layers: Administrative, Transportation, Building, Land cover, Hydrographic, Contour Utility, Cadastral Plans, Orthophoto Maps, Orthophoto Digital Data, Topographic Digital Data etc. They serve the Establishment of control points for various purposes of Surveying and Mapping, Cadastral Surveying, Surveying and mapping for development activities, Topographic and large scale mapping, Digital geo-spatial database support and GIS Development. However, their access is not accessed for free and is not available as open source and therefore their purchase becomes a issue for sharing of their in

house products and services. Department of Urban Development and Building Construction (DUDBC) contain the Digital Base Maps of Kathmandu Valley 16 Municipalities in joint collaboration with the concern municipality and donor agencies. They have National Building Codes and national programmes on Disaster Risk Reduction. Their access to the information from the donor agencies help but yet they do not have Digital Base Maps that resemble the outcome produced in the optimal situations in the contemporary Disaster and geo-information Management Sector discussed in the above paragraphs.

### 5.4. Analysis at Local Government level

In the preparation phase, the Local and Regional Government use spatial data derived from Satellite Remote Sensing produced by International Charter Space, funding agencies, reseller companies and accessed through Web services such as OpenWeb Services (OWS). Similarly they use the baseline data which are produced by Space based information Technical Profile and accessed through Internet and Disaster Portals. Similar is the case with Thematic Maps which are produced by the scientific inputs in such institutions. Local Government also uses the High Resolution Aerial Imagery for Topographic Mapping, the Digital base map accessed through Spatial Information and Mapping Centre and produced by International Development Agencies. In coping phase, the Regional and Local Government use the Spatial data such as Near real-time satellite data; optical and radar data produced by the Satellite/aerial data providers, Space agencies and funding agencies. They are accessible through Community of Web map servers. In recovery phase, Regional and Local Government use the spatial data serving post-disaster activities which is produced by UN platform for Space based Information for Disaster Management and Emergency Response (UN-SPIDER) and accessed through Geo-information Technology Community. They use the High Resolution Aerial Imagery for Topographic data, Post earthquake damage assessment (Detailed Damage Assessment), and Multi temporal comparison. They are produced by International Charter "Space and Major Disasters such as Quickbird satellite image and they are accessible through Geographic Information System, Technical Profile. In adaptation phase, Local and Regional Government are the end users of Baseline data layers, Utility and infrastructure data layers, Disaster specific data layers and Thematic data on terrain and natural resources. They are produced by the Space based information Technical Profile and are accessed through Internet and Disaster Portals. Regional and Local Government use Spatial data integrated with space-based information, spatial data serving post-disaster activities produced by UN-SPIDER and accessed by Geo-information Technology Community as well as Web map servers. Local and Regional Government are the end users of Geo-Portals produced by the Non-Government Organizations and Community Organizations made accessible through Web services such as OpenWeb Services (OWS).

In the case study, Lalitpur Municipality have products and services such as technical and financial support, capacity development programmes, coordination with local bodies and Disaster risk management programmes etc. The formation of accessibility measures through Community Disaster Management Committee, Disaster Risk Management Plans and their coordination to different level of institutions are strong but yet not been parallel to the use of geo-information and earthquake disaster applications.

### 5.5. Analysis at INGO and NGO level

In the preparation phase, Aid and Recovery Community, United Nations (UN) and International Organizations (IO) uses Digital terrain model (DTM) and digital orthophotos through High Resolution Aerial Imagery for Topographic Mapping. Agencies for International Development produce it and National Coordinating Agency for Surveys and Mapping help to access it. Similarly Disaster management Organizations, through Sensors and Database produce products and services related to Environmental factors and Network connectivity. They are accessed by Control System such as telecommunication System (satellite-based, cellular phones attached to sensors).

## 5.6. Analysis at INGO level

In the coping phase, The Humanitarian Organizations apply Rapid mapping activities produced by the Space Technology and Space Agencies and are accessed by the Web services and Reseller Companies. Their management organization uses the Initial assessment of affected population from the Global Population Dataset as well as Local Government (Local Census Datasets) through access elements such as E-mail, web page, Portals on Emergency Management. UN agencies related Humanitarian Organizations use the Pre-assessment maps for data preparation produced by the International and Domestic Data providers such as International Charter "Space and Major Disasters". They are accessed through Web Services. Similarly such International Charter along with Government Departments caters for Initial Damage Assessment by access through Government's collaboration with the UN agencies. Humanitarian or Rescue team or Relief Organizations use the Spatial data of Near real-time satellite data; optical and radar data produced by Space agencies and data providers accessed through communities involved in map servers. The Humanitarian Community use the remotely sensed data provided by the Satellite/ aerial data providers and accessed by good coordinating bodies with proper supporting tools.

In recovery phase, Global Disaster Management Organization use the Google high resolution aerial imagery which are produced by (Google Earth/Map) made accessible through OGC compliant Web Services. Disaster Management Organizations are the end users of airborne remote sensing images which are produced by National Surveying and Mapping Agency, National Academy of Sciences and made accessible by the Geo-information Technology Community. Earth observation for Mapping and Risk management Organizations use the Unmanned Airborne Remote Sensing Images which are produced by National disaster Reduction Centre (NDRCC) or Civil Community and accessed through the internet. The Humanitarian Community use the Field investigation information produced by the Field Teams and accessed through UN Agencies, Government Organizations and Humanitarian Community Coordination Bodies. Disaster Management Organizations and Humanitarian Community use the Daily statistic disaster information by acquiring data through Local Governments and making it accessible through National Government.

In adaptation phase, UN agency related Humanitarian Organization are the end users of Near-real time satellite data and thematic maps produced by International Charter "Space and Major Disasters by making free images available. They are accessed by the end users through GeoRSS Portals, Ad-hoc Web Application and UN agency field staff. The Humanitarian Community and the similar involvement in Command Centres and out in the field are the end users of -Baseline and thematic data integrated both centrally and risk related. They are produed by Government and Non-Government Organizations (NGOs) and International Agencies, Ministry of Civil Affairs Information Centre etc and are accessed through United Nations (UN) GIS Software-based Support System, Earthquake Portals. National Geo-information and Disaster Management Organization, adopts Spatial data infrastructure produced by Data and Software Suppliers, Scientific Institutions and accessed through Networks of Administrative Players. Prevention activities and Disaster Management Organizations use Spatial data integrated with space-based information, spatial data serving post-disaster activities produced by UN-SPIDER and accessed by Geo-information Technology Community as well as Web map servers. Disaster Management Offices are the end users of Enterprise GIS developed through University GeoICT Lab and accessed by National Geological Survey Department. Humanitarian Organizations are the end users of scientific information developed by Technological Institutions and accessed through Open Systems. Humanitarian Organizations are the end users of Geo-Portals produced by the Non-Government Organizations and Community Organizations made accessible through Web services such as OpenWeb Services (OWS).

In the case study, National Society for Earthquake Technology (NSET) has map products such as Seismic Zoning of Nepal, Earthquake Hazard Map of Nepal, Earthquake Intensity Map of 1934 Earthquake in Kathmandu Valley, Liquefaction Susceptibility Map of Kathmandu Valley, Identified Open Spaces (Lalitpur Sub-Metropolitan City), Identified Open Spaces in Kathmandu Valley, Identified Potential Evacuation Sites (Lalitpur Sub-Metropolitan City), Population Holding Capacity of Identified Open Spaces in Kathmandu Valley, Size of Identified Open Spaces in Kathmandu Valley, Usable area of Identified Open Spaces in Kathmandu Valley, Identified Open Spaces in Kathmandu Valley (Usable area of the open spaces), Identified Open Spaces by Ownership, Potential Ground Water Yield Zoning

(Lalitpur Sub-Metropolitan City), Existing Deep Tube Wells (Lalitpur Sub-Metropolitan City), Estimation of Building Damage in Existing Deep Tube Wells Selected for Detailed Assessment (Lalitpur Sub-Metropolitan City), Distance between Recommended Deep Tube Wells and the Proposed Evacuation Sites (Lalitpur Sub-Metropolitan City), Building Age of the Urban Regeneration Pilot Site (Kathmandu Metropolitan City, Ward No. 21 &23), Ghorahi Municipality (South Ghorahi Earthquake Scenario, Mg. 7.2.), Existing Water Supply System (Preliminary Results), Mapping of VDC, Nepal, CBDRR in Kathmandu District Chapter, CBDRR Program Implementing VDCs and Wards in Kathmandu ValleyTheir services are Analysis and management of GIS data/information, Disaster information management for previous years using DesInventar System, Integration/managing of GIS data, Spatial analysis , Production of maps , Risk assessments maps Hazard identification maps Awareness, Teaching, Policy advocacy and Local level disaster management planning (ward/VDC/Municiaplity level). However they are not open systems and their access is not defined. United Nations Development Programme (UNDP) has products such as National Strategy for Disaster Risk Management, Disaster Risk Reduction in Nepal (DRRN) project, Comprehensive Disaster Risk Management Programme and Earthquake Risk Recovery Programme (ERRP). They provide service by establishing National Emergency Operations Centre having established 11 District Emergency Operations Centres, 68 VDCs (Village Development Committees) and over 2000 community volunteers trained on community disaster risk management. A lot has been done on the management and network formation perspective. Access to such products and services are made but yet the geo-information aspect is not met. The World Bank has the product such as Climate Change Knowledge Portal and Earthquake Mortality Risk Map. They serve to provide Climate Adaptation Profile. They help in the access of climate related information through such products and services. However, earthquake disaster and geo-information products and services are not a part of their programme. Practical Action has the products such as Climatic maps of temporal and spatial variations (precipitation and temperature) Ecological zones and whole Nepal. They serve to form different national forums, Advocate policy change and Increase the impact of its operational work. They yet do not have earthquake disaster related maps. International Centre for Integrated Development (ICIMOD) has products such as Geo-visualisation platform for Kathmandu valley for emergency response in the case of earthquake disasters (GeoMountain GeoPortal for Earthquake Emergency Management and Response System for Kathmandu Valley. Their service is the GeoPortal for Emergency response. Such products and services are used in the optimal situation for the global accessibility needs. Disaster Preparedness Network (DPNeT-Nepal) brings the Disaster Related Agencies together and creates network for access to information amongst them. The networking however does not have products and services that allow open system and access to global information. Nepal Red Cross Society (NRCS) is active in the field of networking among the individuals and communities working as Red Cross workers nationally. These individuals and communities are their products to serve for Disaster Impact Reduction. However, they are not trained with geo-information and earthquake disaster knowledge and their implications.

### 5.7. Analysis at Community level

In the preparation phase, Communities involved in Military and similar other applications, use the products and services related to Environmental factors and Network connectivity produced by the Sensors and Database and accessed by the Control Systems based on satellites etc. In the coping phase, the community of GIS specialists use the baseline data produced by the Comprehensive Spatial Database and Ad-hoc web application and accessed through Specific GeoRSS portals from the web pages. In recovery phase, Community Organization use the Google high resolution aerial imagery which are produced by (Google Earth/Map) made accessible through Web Services. Commercial Firms or Communities are the end users of airborne remote sensing images which are produced by National Surveying and Mapping Agency, National Academy of Sciences and made accessible by the Geo-information Technology Community. In adaptation phase, Community of Users of Geographic Information adopts spatial data infrastructure produced by Data and Software Suppliers, Scientific Institutions and accessed through Networks of Administrative Players. Community Policy makers and Planners are the end users of Enterprise GIS developed through University GeoICT Lab and accessed by National Geological Survey Department. Communities involving Institutions and Practitioners are the end users of Space-based Information developed by United Nations General Assembly and accessed through

The United Nations Platform for Space-based Information for Disaster Management and Emergency Response (UN-SPIDER).

In the case study, Flagship 4 (Community Based Disaster Risk Reduction) produces an Information Platform for exchange of information on CBDRR in Nepal. They use the secondary data to identify the hazard prone districts. They serve to the formation of 1,000 CBDRR activities at VDC/municipality level. These secondary data are not however geo-information based but the Flagship 4 does have prospects for a strong networking. The Community of Kathmandu Living lab uses the products and services provided by the OpenStreetMaps. They have the geo-information component and accessibility services through open system that help in purchase of information globally. The Ward level or Local Disaster Risk Management Committee (LDRMC) are active in networking, managing and implementing Disaster Management plans and programmes of the Municipality and VDC, to district levels and community levels through arrangement of training and awareness programmes. They are branching out for a strong managerial committee. However, the geo-information products have not entered the networking or awareness scene yet. *Guthis* are for the community. They are service-oriented. However, their products and services are not devoted towards Earthquake Disaster and topics of geo-information are rare to them.

## 5.8. Analysis at Individual level

In the coping phase, the individuals or the public use the rapid estimate of affected population using updated local census datasets produced by National Statistical Office, Research Institution and Local/Expert Knowledge. It is accessed through research communities. In recovery phase, Individuals use the Google high resolution aerial imagery which are produced by (Google Earth/Map) made accessible through Web Services. Citizens or individuals are the end users of airborne remote sensing images which are produced by National Surveying and Mapping Agency, National Academy of Sciences and made accessible by the Geo-information Technology Community

## 5.9. Conclusion

The chapter presented the differences between the ideal situation where the use of geo-information products and services are compared to the case study in Nepal. It uses the framework containing the information on the institutions involved in the production, sharing and use of the products and services to demonstrate their differences and shows the gap present. The gap is discussed in the following chapter to include community resilience that has implications in the case study area. The discussions are made in the context of the products and services produced, shared and used.

# 6. DISCUSSIONS

The chapter discusses on the gap identified between the ideal geo-information products and services, their production, sharing and use among the Disaster Management Institutions around the world at the present and the case study area in Nepal. Initially, the discussion is on the framework developed in chapter three. Secondly, the issues related to community resilience such as social capital, social resilience and resilience are discussed among every level of institutions raging from the international, national, local, community as well as the informal institutions that are recognized in the society.

## 6.1. Discussions on Community Resilience in the National Government Level

### 6.1.1. Social Capital in the National Government Level

Within MoHA, National Strategy for Disaster Risk Management in Nepal (NSDRMN) is a trusted strategy that endeavors to achieve the goal of disaster resilient Nepal. They want to improve the policy and legal setting and come up with significant norms. They also want to prioritize the strategic interventions and produce relevant information. It plans for institutional reorganization and development and also strategic improvement policy and legal setting that exists in the present. This encourage in planning for disaster risk reduction (DRR) and preparedness in every level of institutions involved. It aims towards disaster reduction and emergency response planning and capacity enhancement. It wants DRR strategies mainstreamed in the national development considering the usefulness of social ties among them. It aims towards disaster reduction and emergency response planning and capacity enhancement to be able to sustain under probable difficult conditions and thereby have a social capital. Though the strategy follows cross-cutting issues and recommends to mainstream DRM but yet do not convey the details of application of geo-information. The strategy does not consider the semantic and standard use of terminology for geo-information in GIS. However under the Cross-sectorial strategies for DRM, in Priority Action 2: Identify, assess and monitor disaster risks and enhance early Warning within Strategic Activity 9: Establish and institutionalize an authentic, open and GIS based Disaster Information Management System (DIMS) at the central, district and municipal levels to cover all disaster-related information, GIS use has been focused showing concern towards GIS application in Disaster Risk Management in Nepal.

MoFALD has the Disaster management and Municipal Planning Section. It has disaster risk management guidelines for disaster risk planning at the local level. It shows its social ties of the municipality with the local level with the help of which social capital is developed. However, the disaster risk management guidelines do not have the use of geo-information in the disaster risk planning at the local level yet. They have been involved in the mapping 75 districts by using GIS with administrative boundary, land utilization, river and road. Though norms are developed in the form of guidelines, the information is not sufficient for geo-information related work and therefore no trust in the semantic and standard use of geo-information related GIS terminologies in this sector.

The Survey Department has the uniformity in the mapping procedures and coordination showing their value for norms. They work for improving the quality of finished product by avoiding duplication and have built trust. They access and disseminate the information through an environment of coordination with different government organizations even at the worst conditions to build social capital. They produce maps and use GIS technologies. However, semantic and standard use of terminology for geo-information in GIS is only limited in their own department.

DUDBC have prepared the Building Construction Guidelines that have developed norms by the department for national use. Building construction trainings have been conducted among 500 mansions to build more houses and trust, altogether to gain social tie. The information is however limited due to language barrier, having only a Nepali version of the guidelines. This has degraded the information dissemination activities and is only limited to a certain Nepali community. They have formed Digital Base

Maps of Kathmandu Valley and 16 Municipalities in joint collaboration with the concern municipality and donor agencies. However lack semantic and standard use of terminology for geo-information in GIS.

### 6.1.2. Social Resilience in the National Government Level

Nepal having made commitments in an international convention and forums such as the Hyogo Framework of Action (HFA) 2005-2015 and UN "Cluster approach" for achieving goals and creating equivalent working groups from the institutions for coordinating efforts. MoHA applies them in its priorities and strategies elaborated in NSDRMN. It emphasizes on developing and enacting National Integrated Disaster Response System and a robust communication system to enhance response capacities upto VDC level communities. It is elaborated in the Priority Action 5: Enhance preparedness for effective response has Strategic Activity 24: Develop and enact National Integrated Disaster Response System, Strategic Activity 27: Establish a robust communication system that can be used and Strategic Activity 29: Enhance emergency response capacities of communities at the VDC level. However they have not used the modern crowdsourcing technologies and are still building on the face-to-face interactions. Social resilience in such scenarios can be attained through virtual interactions in addition to the face-to-face interactions.

MoFALD has disaster risk management guidelines for the purpose of planning in disaster risk activities at the local level. The guideines direct the government agencies, development partners and non-government organisations on formulating and implementing plans for disaster risk management. It has therefore a widespread network through, Local Disaster Risk Management Planning guidelines (LDRMP) and District Disaster Risk Management Plan (DDRMP), Community Disaster Management Committee (CDMC) reaching to the grass-root level for achieving a social resilience among the various levels of institutions. Information is communicated well through MoFALD but the guidelines have not yet analysed the present concepts of attaining social resilience through the use of tools of crowdsourcing information both nationally and internationally by techniques such as VGI, UAV etc.

The Survey Department uses the Global Navigation Satellite System (GNSS) in Disaster Management for surveying and mapping activities. It is disseminated among the professionals, policy planners and decision makers for crating social resilience. The communities or the individuals are not facilitated with such tool. An overall social resilience can be achieved only if such tools and their knowledge and trainings are disseminated to the grassroots level.

DUDBC creates relations with the various municipalities nationally to disseminate National Building Code (NBC). However, the dissemination of information is limited to municipalities and VDCs from the resources supplied by DUDBC. The application of NBC in those DUDBC communicated municipalities and VDCs and their status check for attainting social resilience is not sought. Crowdsourcing methods can have an impact in such scenarios.

### 6.1.3. Resilience in the National Government Level

The strategy of NSDRMN under MoHA suggests that an institutional mechanism is required to be put at place filling the gaps present in the existing DRM structure. It requires cross-cutting issues to achieve the vision of a "Disaster Resilient Nepal". Such cross cutting issues are elaborated in the Priority Action 3: Better knowledge management for building a culture of safety, the Strategic Activity 16: Develop plans, programmes and facilitate for use of mass communication media for dissemination of information on disaster risk and risk reduction. Various institutes such as GoN ministries and departments, local-level government offices, the corporate sector, national and international organizations, NGOs, Community Based Organizations (CBOs), vulnerable communities, UN agencies and the external development partners (donors) and individual citizens share the responsibility and support of DRM. The information access and dissemination within these vast levels of institutions and organizations require mass through the use of open systems such as Open Data for Resilience Initiative (OpenDRI). Resilience in present technology base requires open systems to be achieved fully.

MoFALD achieves resilience by being the focal organization that promotes local development and decentralization. It has approved guidelines of Local Disaster Risk Management Planning (LDRMP) with the help of which it strengthens the community resilience by enabling its consultation for planning for disaster management. However, community consultations through open systems are not present in the guidelines. Therefore the present technologies of open data sharing system development cannot make a breakthrough for achieving the resilience needed at present.

National Geographical Information System (NGIS) operation strategy built by Survey Department communicates with various agencies but is not open to the public or the community. In such condition, data sharing will not be wholesome due to the presence of outdated information and gaps. Such system should apply the impact built in Open Data for Resilience Initiative (OpenDRI).

DUDBC working for strengthening of legal framework of NBC-Building Act 1998 work to guide municipalities in NBC implementation. The guidelines however are not open to public for making amendments for a resilient implementation and correction. Open data sharing, access and dissemination among the communities residing in the municipalities of implementation as well as the global community can assist for resilience.

## 6.2. Discussions on Community Resilience in the Local Government Level

### 6.2.1. Discussions on Social Capital in the Local Government Level

LSMC through the formulation of the framework of Disaster Preparedness and Response Plan Framework (DPRP) makes its own norms. It assures for trust towards the participants representing various organizations, departments, institutions, donors and Nepal Government to work in a collaborative efforts and implement and work for the improvement of the framework. It also informs through the development of framework, a message that it would be a model for implementation in the neighbouring municipalities. However, it had a priority in the sector of availing safe water Lalitpur during an earthquake disaster. In addition, though the social ties and the social capital were formed, they were not implying on having a semantic and standard terminology use and to base on using geo-information through the use of GIS in the framework. Maps such as Selected Evacuation Sites and Deep Tube Wells in Lalitpur Sub-Metropolitan City for earthquake Emergency were developed for preparedness and response activities but the social capital was not dealt in the levels of using semantic and standard terminology in the work that comes ahead.

### 6.2.2. Discussions on Social Resilience in the Local Government Level

LSMC has formed the ward level disaster risk management committee (WDMC) in few of the wards. It wants to foster though the creation of new relations with the communities of the wards. It wants to achieve a social resilience by capacity enhancement of the WDMC and volunteers. The volunteers are involved in designing activities related to disaster risk reduction and preparedness. The capacity enhancement is limited to the sharing of disaster related activities through person to person. The capacity enhancement methods and information sharing through the present advancements for a better social resilience is not yet a part of their framework.

### 6.2.3. Discussions on Resilience in the Local Government Level

LSMC has implemented Community Based Disaster Management Program in WDMC. The purpose is to have disaster safety in such communities. It is done through awareness campaigns and training programmes. Community resilience has been initiated through the process of institutionalization of such communities in the local government sector such as LSMC and a continued effort. However, the system is not open and limited to the frameworks and plans developed in the higher level institutions. Such communities need trainings that are based on the lessons learned and the use of open systems.

## 6.3. Discussions on Community Resilience in the Humanitarian and INGO Level

### 6.3.1. Discussions on Social Capital in the Humanitarian and INGO Level

World Bank builds trust under difficult conditions through mitigation activities enhancing the government's capacity in vulnerable climates through weather forecasts and early warnings. These weather forecasts are brought from Climate Change Knowledge Portal and Climate Adaptation Profile having global norms in order to build social ties globally. There are cases information dissemination is made through the development of information system services in priority sectors such as agricultural management. This enables the farmers to apply mitigation measures in their day to day lives and build social capital. However, these activities are limited to climate related hazards and agriculture management and not in disaster management. Therefore, the semantics and standard use of terminologies are irrelevant.

UNDP works on the norms for reducing disaster risks through policy. They also build trust by supporting the community level efforts by information dissemination through their own projects. They are Disaster Risk Reduction in Nepal (DRRN) project which is continued by Comprehensive Disaster Risk Management Programme along with Earthquake Risk Recovery Programme (ERRP). They have a social tie with the government level by focusing on policy and institutional strengthening referenced to the National Strategy for Disaster Risk Management building a social capital Therefore there is a standard use of policies and information. However, they do not include semantic and standard use of terminology for geo-information in GIS in their projects.

Practical Action has developed Early Warning Systems (EWS) in DRR for building resilience among people suffering from such vulnerabilities for generating trust. Climatic maps of whole Nepal, temporal and spatial variations (precipitation and temperature) and ecological zones are used for access to information and dissemination. Similarly, they form national forums and advocate for policy change to increase the impact of their on-going work. However they do not use standard semantics and terminologies but are positive towards advocating for policy change and having a social capital.

ICIMOD is a regional resource centre for geo-information and earth observation application building policy and norms on mountain. They access and disseminate information from Geospatial Solutions. They have Geo-visualisation platform for Kathmandu valley for emergency response in the case of earthquake disasters. The portal is called GeoMountain GeoPortal for Earthquake Emergency Management and Response System for Kathmandu Valley. They have built trust among the national government by working for science-based decision making by institutionalizing remote sensing and geographic information systems supporting the development policies.

### 6.3.2. Discussions on Social Resilience in the Humanitarian and INGO Level

World Bank works for the modernization of the observation networks and forecasting in the sector of Department of Hydrology and Meteorology (DHM). Capacity building of the personnel involved in the future network operations for project implementation is a priority task. It wants the service delivery with the use of modern networking and forecasting enhanced system for information services to the communities and institutions highly affected by it. However it does not work on Disaster Management with the same vision of modernization, operation and implementation. It fosters to build on the new relations based use of tools and techniques which are globally recognized today for a secured social resilience.

UNDP applies its capabilities of disaster risk management in government ministries and local bodies through strengthened relations and communication. Comprehensive Disaster Risk Management Programme focuses on social inclusion and knowledge management. 68 VDCs (Village Development Committees) have received support to become disaster resilient. Similarly over 2000 community volunteers trained on community disaster risk management. However, the access and dissemination of social inclusive knowledge and management remain less resilient due to the absence of crowdsourcing activities such as VGI.

Practical Action priorities involve mainstreaming of DRR activities into Development Planning. They foster through institutional sustainability and communication integrated activities of DRR and climate change with development planning. In spite of such opinions, crowd sourcing activities have not yet been undertaken for Climatic maps.

ICIMOD with the help of global innovation such as GeoPortal for Emergency response communicates information and applies it in the regional socio-cultural context. Research based information is shared among the levels from youths, partners, policy makers and decision makers. Therefore it fosters through new innovations and is open to build social resilience through crowdsourcing initiatives such as a GeoPortal.

#### 6.3.3. Discussions on Resilience in the Humanitarian and INGO Level

World Bank works for Building Resilience to Climate Related Hazards for communities at risk. It works on agriculture sector for creating Agriculture Management Information System (AMIS). Multi-hazard information, early warning systems and other agriculture related systems are utilized for decision making. Disaster Management Information System is not yet created but such innovations in agriculture sector initiates possibilities of Earthquake Management Information Systems for managing community resilient disaster management. This asserts for a possible open system for disaster management for achieving community resilience to balance todays need and culture of open information sharing.

UNDP has established National as well as District Emergency Operation Centers and they are in increasing number. These coordinate DRR and planning well but the system is not open. Therefore, the resilience is not achieved with respect to the technological advancements applied globally at the present. Such mechanisms can be integrated with Open systems for building resilience.

Practical Action focuses on building resilience for the earthquake vulnerable communities. They choose to work under the priority action and strategies of NSDRM and work through community based approach making use of their capacities for disaster response. However, their capacities are not fully utilized as per the present global innovation and needs. These communities are yet to be supplied with knowledge on open system to enhance their resilience and data sharing capabilities.

ICIMOD manages and communicates knowledge through its open house information such as online publications, databases, multimedia, and web content etc. It is based on accepting innovations that improves communication of knowledge through interactive tools and technologies. An example can be Open systems for building resilience such as Open Data for Resilience Initiative (OpenDRI).

### 6.4. Discussions on Community Resilience in the NGO Level

#### 6.4.1. Discussions on Social Capital in the NGO Level

DPNeT-Nepal is a facilitator to Disaster Preparedness activities. It is responsible for creating a social tie among the institutions involved. They promote and advocate principles and stick to the norms, share experience and gain trust and spread information on sustainable disaster management. They want to create a social capital by focusing the workshops and meeting's activities by linking disaster management to developing activities. These activities have not yet focussed on issues of geo-information and semantics or standard terminology use in GIS.

NRCS being the largest humanitarian organization in Nepal has built trust from its wide network of organizational support to the 75 districts from District Chapters, sub-chapters and the committees working below them. Volunteers including schools, campuses and communities access and disseminate information. Their norm focuses on building social ties to the grassroots level and a social capital. However, it does not mention the use of geo-information or GIS, let alone their use in standard terminologies or semantics.

NSET disseminates knowledge and information to a wide network of institutions and thereby build trust. They advocate and establish norms for resource access and dissemination by maintaining credibility for building social tie and then social capital. The resources are in the form of projects involving credible documents, training or maps. These maps are based on the principle of geo-information in earthquake disaster management. They make a semantic and standard use of terminologies of geo-information in GIS but do not have a national impact due to the absence of policies in the need of map making in the national government level documents such as NSDRMN.

### 6.4.2. Discussions on Social Resilience in the NGO Level

DPNeT-Nepal develops linkages and networks with disaster related institutions both nationally and internationally. They foster through the creation of such linkages as they organize trainings and improve communications through access and dissemination of information among the relevant institutions and make them socially resilient. This is a form of crowdsourcing but not in the sense that they use social media or similar interactions in such disaster related activities.

NRCS creates social resilience by the Network of Red Cross workers throughout the country. They expand and strengthen the social organization of the vulnerable people by linking their communities with the organizations both government and non-government. This is a method to crowd source information from the communities to the people but this does not apply the measures such as social media.

NSET creates social resilience among two highly related sectors such as Urban Disaster Risk Management (UDRM) and Geographical Information System (GIS). It works by creating maps that communicate information fostering relation among the two. They access data and information from their network of institutions but have not used crowd sourced geographical information from VGI or social media etc.

### 6.4.3. Discussions on Resilience in the NGO Level

DPNeT-Nepal publishes the prepared and updated resources to the institutions and individuals associated in sustainable disaster management and development. They build for community resilience through sharing of information and resources. However they are not open systems where publishing of news, views and experiences can be done by the institutions or individuals that are not involved in DPNeT-Nepal or even the international institutions or individuals.

NRCS work for the reduction of the disaster impact, utilize community participation and mobilize volunteer. They focus on their increment for community resilience. However, they do not use the modern technology of open systems with the help of which there is increment of volunteers and increment of information for necessary reduction in disaster impact.

NSET is working extensively in earthquake disaster management and involving technically and socially sound professionals and institutions. Mapping activities of geo-information in earthquake disaster management is a priority and therefore they strive for earthquake safe communities in Nepal by 2020. They give trainings in a wide range of earthquake disaster management activities but concern has not been given to the open system for building resilience by using open data initiatives that is recognized around the world in disasters of today.

## 6.5. Discussions on Community Resilience in the Community Level

### 6.5.1. Discussions on Social Capital in the Community Level

The ward committee involves discussions among the participants, the representatives from community members, neighborhoods, tole sudhar samiti members, guthi members, club members, community based organization members, ward secretaries, LSMC members. The committee has a set of rules and regulations and is trusted for it is formed through a consensus among a group of representatives and are also oriented with the information regarding Disaster Management. The social tie is formed, works are cssonducted but their activities are mostly limited to trainings and awareness based on the framework

which does not have mapping activities which is important to reach the next level of standard use of terminologies in geo-information and GIS activities.

CBDRR, Flagship 4 focuses on access to Disaster Risk Reduction (DRR) information and social ties formulated as result of mechanisms of coordination among the institutions. It is the Information Platform for exchange of information on CBDRR in Nepal. They have involvement in DRR information access and dissemination from the national level to the community i.e. grassroots level enforcing social capital. Since GIS is not used in the Flagship 4 programme, so use of semantic or standard use of terminology for geo-information in GIS is absent.

Kathmandu Living Labs (KLL) is working as a community of technical specialists initially in the mapping activities of Kathmandu valley using OpenStreetMaps application. They build social ties with the domain experts and deliver solutions to the national problems. They use the semantic and standard use of terminology in OpenStreetMaps. Such standard use is not yet applied in the field of Disaster Management.

### 6.5.2. Discussions on Social Resilience in the Community Level

Wards, through LDRMC have volunteers that participate for disaster management training. It wants to foster through volunteer or individual knowledge and awareness increment in the disaster aspect. Since it is the lowest level of communicate information, it always remains in the shadow and less representative in the long run. They therefore need to be updated with VGI, a method of crowdsourcing, to enable frequent information flow to be a part of active network and socially resilient.

CBDRR, Flagship 4 has Organisational base at Village Development Committee (VDC) / ward and community level. It fosters through the creating of new relations by access and dissemination of information through social resilience among them. Using the resources within the organizational bases, Project Mapping of CBDRR/M activities are conducted to collect information related to their geographical location. Such activity assists for identifying gaps of geo-information regarding CBDRR/M activities which are of concern to the partner and donor agencies. Similar CBDRR/M sites can be traced and mapped by volunteers among the community itself if they have the knowledge and information regarding crowdsourcing.

KLL is fostering through the connecting activities with new partnerships from a global network comprising of innovation, techniques, knowledge and volunteers. They work for social resilience through crowdsourcing activities making use of open software, mobile and internet facility globally.

### 6.5.3. Discussions on Resilience in the Community Level

Within the LDRMC, the volunteers participate in the Vulnerability and Capacity Assessment (VCA) and undergo trainings ad workshops. Methodologies on VCA is also carried as a field study as an exercise to gain extensive knowledge on Disaster Management and to have a resiliency as a community volunteer. In spite of application of such programmes, the volunteers are not resilient enough because they do not have an open system where knowledge and trainings should be based on lessons learned from the disasters in the nearest past. The contemporary issues give priority to open systems which allows interested volunteers not just from the community but even the neighbouring communities or even the global communities.

CBDRR, Flagship 4 have completed 1,000 CBDRR activities at VDC/municipality level. Community based early warning systems within these CBDRR communities add to the information of early warning systems in the national, local, district, municipality and VDC levels. This builds community resilience. However, these information of early warning systems within these levels need to be added and updated for resilience development throughout. This requires an open system of data and information collection regarding early warning knowledge dissemination. This can be achieved both nationally and even internationally.

KLL campaigns for the open data initiates in Kathmandu and with the use of the civic technology aspire to have community resilience. With the help of open source applications such as OpenStreetMaps, they create access and disseminate open data and open maps for open use with emerging open web and mobile technologies. They use open systems for building resilience with Open Data for Resilience Initiative (OpenDRI) in disaster induced situations globally.

## 6.6. Discussions on Community Resilience in the Informal Community Level

### 6.6.1. Discussions on Social Capital in the Informal Community Level

Since the involvement of *Guthis* are based on culture and traditions to develop, operate and sustain their involvement in activities, there is a trust level in the communities. They are basically involved in the religious, social and physical infrastructure and therefore have the required information for running other related activities, too. However there are no clear policies in the development and implementation of activities in *Guthis*, so they do not operate on the basis of norms. A social tie is present in activities run by them. A social capital is formed by their efforts in effective channelling of wealth of individuals for the use of public services such as buildings, water supply, cleanliness and drainage through a a rapport with the permanent committees. But since it is not a part of the formal institutions, their activities also do not meet the standards officially but do make a lot of sense in the community.

### 6.6.2. Discussions on Social Resilience in the Informal Community Level

Guthis are Informl Community based Organizations since they donot belong to any of the institutions. However they work for the community and have various sectors such as Religious *Guthi*, Service-oriented *Guthi*, Communal *Guthi*, entertainment-oriented *Guthi*. For e.g. in the Service – oriented/Social *Guthi* such as *Sie-Guthi,* is primarily focussed on cremating the dead bodies among the members of the *Guthi* for providing help to the members in difficult conditions. Practically, the *Guthi* membership is defined by the hereditary issues i.e. only the people belonging to the same caste. However, the migrated or the local population also enter and become a member of the community related *Guthi.* This shows their ability to foster through the creation of new relations and is open to newness and future plans such as job creations etc for the betterment for the *Guthi*. They are socially resilient and also allow for generation of new ideas, applications and tools.

### 6.6.3. Discussions on Resilience in the Informal Community Level

*Guthis* being flexible, they participate in varying degree of activities. A prominent one is the construction of urban spaces such as water bodies, temples or roads etc. This is a contrast to the cultural activities that they are actively involved in. They can accept change easily and are keen to introduce modern systems and committee formations. An example would is the formation of sub-committees such as sports sub-committee for attracting the young generation towards the culture and tradition of sustained membership in *Guthi*. As the principles and practices of *Guthi* is transferred to modern practices, the participation of people within such activities tend to grow. A participatory approach through open systems application would be attractive to the readymade *Guthis* with deep rooted cultural system. Adoption of new and open system to improve the resilience of the communities through the *Guthi* having closed and bonded communities is preferred at present. The proper use of local and the institutional resources with participatory approach will guide development in right direction.

## 6.7. Reflection on the Gaps of the Available compared with the Optimal status of Geo-information

- **National Government level**

In the preparation phase, there is a greater use of Political deals and agreements which are made in certain aspects of Disaster Risk Management through National Strategies. Yet they are not concentrated on the availability of the products and services of geo-information required for earthquake disaster preparation. Local SDIs are not produced by national governments which are typically focused on Disaster, let alone Earthquake disaster and geo-information. Maps are available but are not simulated by making use of

national resources but are usually accessed through global network of International Charters. Therefore there are no developments of scenarios since simulations themselves are absent. Disaster prevention activities are at place but not yet accessed through open sources. Information of remote sensing are available from the National Survey Department. In the coping phase, maps are produced through National resources whereas simulations need the help from other Disaster Management Agencies. They do not have internet website map on volunteer data. Information and map on damage of disaster are purchased through network of agencies. They do not have Standardized data formats for timely information flow for minimizing destruction to lives and property. However have provision for real-time satellite data and imagery since the national government acquires it from the International Charter or member nations. They have the capability of interpreting and extracting information and have capabilities to undergo infrastructure assessments such as evaluation of the usability of roads. Similarly, asset mapping such as hazard mapping are assisted by the Organizations involved in geo-information which are among their network of organizations. They do not have nationally produced information on hazard risk through risk inventory. However, their accessibility is possible through global networks though their nature is not an open source. In the recovery phase, maps are produced but simulations are not considered as a priority therefore scenarios development is not carried out because of the nature of the plans and policies in the National government level. The disaster maps are based on satellite maps and Google Maps are not used a source of images in the National level. Standardized data formats for timely information flow for minimizing destruction to lives and property are not a part of their priority. Similar is the case with Open source mapping (OSM). Remote sensing techniques are used for land use in urban planning purposes but not yet for visualizing the Land cover change. However, initial information are derived from remote-sensing data for further visualization by using added values of other techniques such as aerial photography. In the adaptation phase, there are no formal semantics of data since they are involved in Disaster Reports and do not have semantics of data discussed. The maps are present but they are not based on simulations because such scientific institutions are not available in National Government. Though they are branching for networking activities, but have not considered VGI resource investment. Geodetic Control data are available but are not sufficient for earthquake disaster and geo-information accessibility. Disaster prevention activities are there but not entirely focussed on earthquake disaster and geo-information use. Land cover maps are available but the risk assessment maps on earthquake disaster are not accessed yet. Application of rremote-sensing data is used for formation of maps and data collection such as Orthophoto Maps, Orthophoto Digital Data, Topographic Digital Data but are not flexible in accessibility due to close systems. Services such as aerial photography survey and products such as Digital elevation Model (DEM) is used but their open accessibility is yet not possible.

- **Local Government level**

In the preparation phase, local authorities are involved in contingency planning and disaster preparedness but are not focussed on Earthquake disaster and geo-information products and services. Similar is the case of coping and recovery phase to that of National level. In the adaptation phase, yet the local authorities are not aware of the Participatory mapping for detailed neighbourhood maps and Hybrid participatory Mapping.

- **INGO and NGO level**

In preparedness phase, in the INGO level, a lot of work has been done related to preparation phase such as acquisition of Satellite images and production of maps. However, they have not yet used open source web applications such as OpenStreetMap. In the response phase, maps are produced by observing of satellite images as well as Google Earth. However, there is the absence of use of social media such as twitter or ad-hoc Disaster Management websites. Similarly, semantics of Geo-Information infrastructures are absent. In the recovery phase, maps are produced but they do not yet use the Portable Navigation Receivers to produce them. They are also not served with Natural disaster databases based on the case study area. In the adaptation phase, GeoPortals are used for the sharing and contextual adaption of Information/ application methodologies but they are very few and not flexible enough to adapt to the context. There are maps but still are not enough to adapt.

- **Community level**

In the preparation phase, OpenStreetMap are produced by the community and shared through them among the individuals and levels of institutions through their open system web applications. In the coping phase, there are strong networks but do not yet use VGI through Civil society. Similarly the grassroots communities do not use the products and services involving UAV. Similar is the case with the recovery phase. In the adaptation phase, there is absence of the Scientific Community that can establish methodology and check reliability of VGI.

- **Individual level**

In the preparation phase, yet there are no services available for GPS popularization through citizen participation using VGI. There are Web services such as OpenStreetMap assessable to the individuals and assisted by them for their workability. However there are no individuals involved in products and services such as internet based GIS and satellite images. In the response phase, there are volunteers in the grassroots levels but are not directed towards collection, sharing and dissemination of data through VGI. They use Social media but are not trained to use it for earthquake disaster and geo-information accessibility perspective. There is no awareness and training available to the individuals for land-based mobile mapping systems. In the recovery phase, there are individuals involved in volunteering but not trained as to acquireVolunteer Geographic Information (VGI). Individuals are not made award of the products and services such as GPS mobile phones with embedded GPS including digital cameras and tracking devices that help in access of geo- information in the context of earthquake disaster. Individuals in the adaptation phase are not capable to volunteer or producing maps on damage updates using the interfaces by combination of Google Earth and available high-resolution satellite images. The services are available but the methodologies on how to use these services are unknown.

## 6.8. Conclusion

The chapter discusses on every level of institutions involved in Earthquake Disaster Management and the focus is towards community resilience. It clarifies the aspects of having networks that reach to the grassroots levels. It discusses on the workload carried out by the institutions in Disaster Management sector, mostly on the structural and social aspects by undergoing community resilience activities through trainings, structural measures, awareness and knowledge sharing as well as the development of network. However, geo-information products and services are minimal and their sharing is not compliant to the open systems. The gaps could however be filled by local knowledge and awareness dissemination on the aspects of open systems of information and global sharing. This should be enacted through the Informal Community based Institutions. Better provision and Dissemination Strategy of Informal Institutions should be applied on *Guthis* since the individuals who volunteer for making the geographic information available and accessible are attached to them. The following chapter on the conclusion and recommendations highlight these aspects in the form of summery for a better understanding of the gaps present between the ideal scenario and the scenario of the case study of the disaster and go-information community of Nepal.

# 7. CONCLUSIONS AND RECOMMENDATIONS

### 7.0. Introduction

The conclusion of the research is given focussing on each objective. The main objective of the research is to analyse the present status of geo-information relevant for community resilience. To achieve the main objective two sub-objectives were formulated. The research laid to the conclusions as mentioned below:

**1st sub-objective:** To perform an in-depth analysis of the current role of geo-information products and services, and related sharing practices

a. What are the issues of geo-information in Disaster Risk Management?

The issues of geo-information in Disaster Risk Management are the methods of information sharing, technical advancements and capabilities, policy formulation and guidelines implementation, status of integrated awareness of geo-information and Disaster Risk management. In the overall sense, the issues are visible in the gap between the best practices of geo-information in Disaster Risk Management and the ones that are learning from those best practices.

b. What are the products and services applicable in DRM?

The product and services applicable in DRM are elaborated in the third chapter on Framework of Community Resilience and Lessons learnt in Earthquake Disaster. They differ with the variation in the stages such as Preparedness, Response, Relief/Recovery and Mitigation. Some products and services are used repeatedly while some are used as per the context and current technological advancements. They however differ subsequently with the institutional organizations, their structure and their flexibility towards innovative and contemporary advancements.

c. Where is the status of geo-information in planning practices in DRM institutional structure specifically in earthquake disaster?

The planning practices in DRM institutional structure for forecasting, early warning, mitigation, pre and post geo-information requirements are studied from the Lessons learnt in Earthquake Disaster. It shows that a strong national institutional base of earthquake DRM is necessary for humanitarian activities to take initiatives during the disaster. The status of geo-information in planning practices in earthquake DRM institutional structure prepares for a nation enabling highest possible assistance during crisis/emergency situations.

**2nd sub-objective:** To determine the gap between the desirable geo-information and currently available geo-information products and services and related sharing practices at each institutional level and the in earthquake disaster risk management phases and reflect on the roles of geo-information for community resilience

d. How is geo-information accessed within the institutions in similar scenarios such as in the case of earthquake disaster in Haiti and China?

In both the scenarios, geo-information are accessed through space technologies, national and global inventories, participatory mapping methods, open source systems, SDI, geo-portals etc. The geo-information is accessed as per the timely information need. However, the nature of central government defines the accessibility, dissemination or sharing abilities of all the concerned parties for those time and situation specific information.

e. What are the roles of geo-information in Community Resilience?

The roles of geo-information in community resilience are basically to facilitate an environment of trust that enables the formation of new relations and work among the systems that are open to change and time specific.

f. How are institutions lacking geo-information sharing practices in earthquake disaster risk management phases and where communities can help?

Institutions of DRM have various structural organizations with a varying degree of networking capabilities and therefore a variety of sharing practices. The deficiency is in the national government initiatives. Firstly, they do not have a policy that is specific towards geo-information, let alone its integration with earthquake disaster risk management phases. Since the top bottom approach is not justifying the need of time, the bottom top approach does have a possibility to conceal the gap. The communities use participatory approach through crowdsourcing such as VGI, social media and web services such as OpenStreetMaps and geo-portals etc to share data and information nationally and globally. However, there are communities where technical advancements and knowledge become tough to accommodate. Therefore, the communities that are already embedded with an organizational structure of social capital and social resilience should be targeted.

## 7.1. Findings

There are basically two main findings that have emerged out of this study. Firstly, all the institutions involved in DRM lack the access to sharing of geo-information during earthquake disaster and have lesser community resilience. This is basically due to the absence of geo-information related policies in the national government. This has created a gap between the best practices and the practices involved in the research area. Secondly, there is the need to give attention to the informal institutions in the case of a transitional society like Nepal which is seeking to adopt modernity but it is still in the grip of tradition. In the past, all social works were undertaken by this informal community based organizations such as *Guthi* which have worked as an efficient system with a clear line of command and control which has evolved over the years. The abandonment of this system for the adoption of the modern one has created problem. This should prevail especially in disaster situations where close ties work very effectively. Participatory mapping through OpenStreetMaps and similar apps should be initiated through these communities. Social ties in the community help to strengthen the information. These technologies should be launched from such basic institution involved in the network of higher institutions. For a successful implementation of the innovative ideas such as OpenStreetMaps, the initiation should start from the *Guthi*, involving people who are related, to overcome the issue of trust, information etc.

## 7.2. Recommendations

On the basis of the aforementioned study, the following recommendations have been made

- In the study area, geo-information related to earthquake disaster risk management is available with selected government and non-government institutions but these should be made available and accessible to the informal communities like *Guthi* to be capable enough for sharing practices. However, these tools should have participatory approach and open systems.
- There is a gap of accessibility to geo-information when compared with the best practices and the practices involved in the research area. There are few instances, where they have only been available in scientific study and should be accessible in practice.
- There should be an integrated unit in the national government level i.e. MoHA addressing the earthquake and furthermore a national unit in geo-information in earthquake disaster.
- Informal Community Organization, *Guthi* should be represented in all the levels of Disaster Risk Reduction (DRR) institution starting from the local like LDRMC to the central bodies like CDRC.
- Map based training should be provided to larger number of individuals belonging to communities of *Guthi* as it has been found to be very effective in the study.

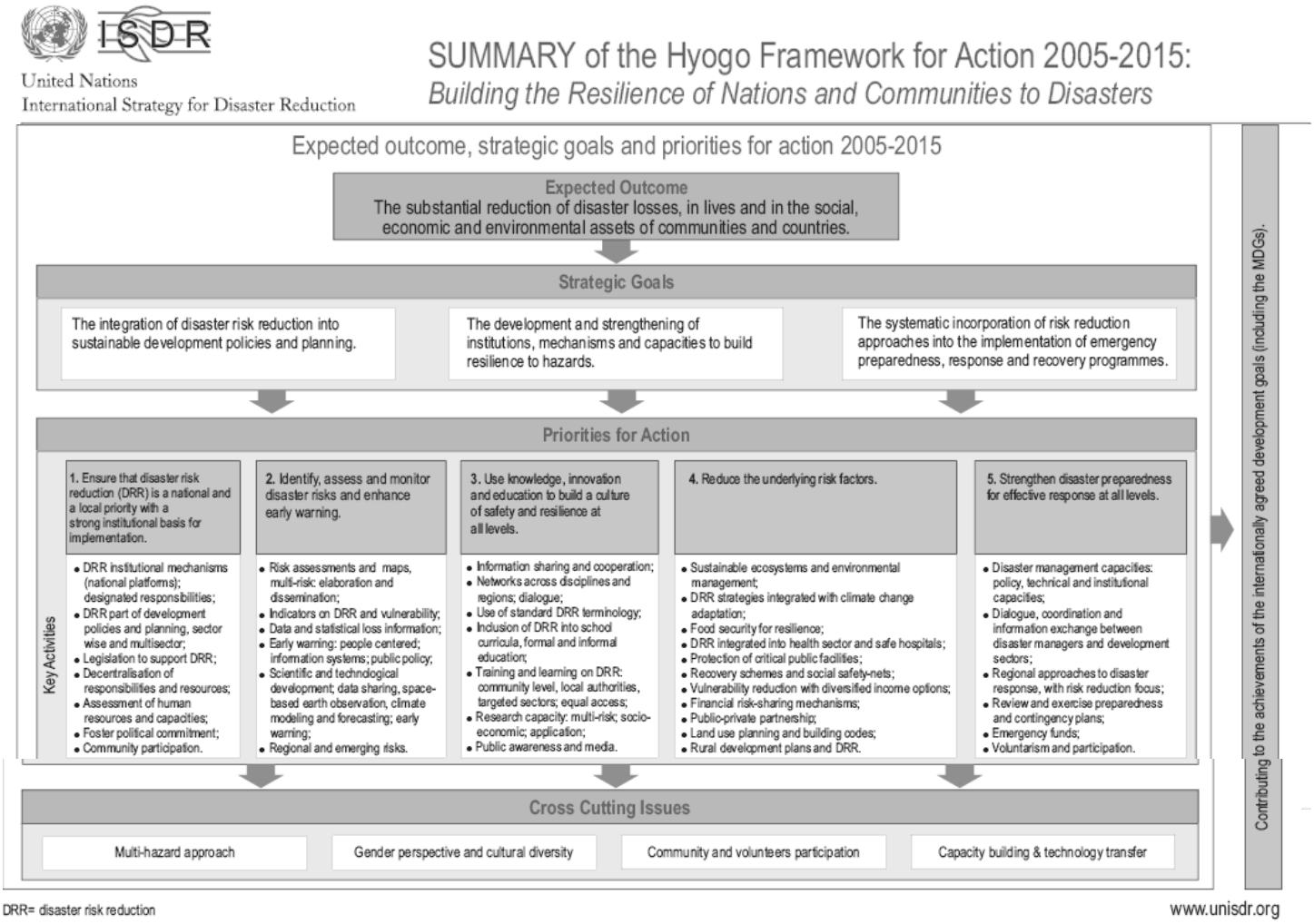
## 7.3. Further Research

The further research can be as follows:

- Accessing the participatory approach and open systems of geo-information sharing practices in earthquake situations.
- Securing representation of the ignored traditional informal groups in DRM institution.
- Analysing the structure of a geo-information and earthquake unit in the Disaster Risk Management (DRM) organization in view of the prevailing and drafted legislations.

# APPENDICES

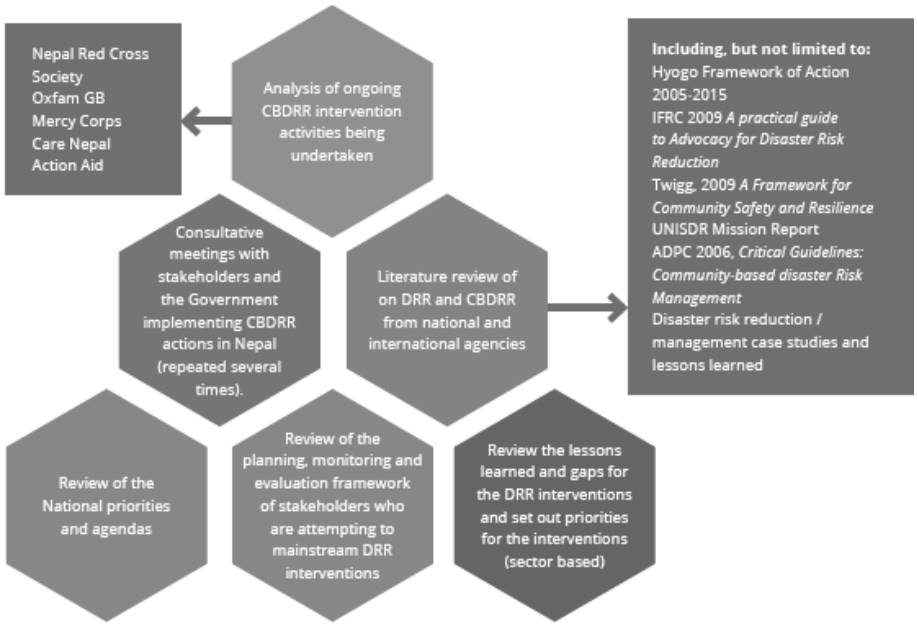
**Appendix 1.** Summary of the Hyogo Framework for Action 2005-2015




**Appendix 2.** Nine minimum characteristics of disaster resilient community in Nepal

**Appendix 3.** Minimum Characteristics of Development Process

FIGURE 2: **Minimum Characteristics Development Process**




**Appendix 4.** **Interview with institutions, study area and buildings**

MoFALD

Municipality

NSET (NGO)

MoHA

Municipality

UNDP

Nepal Red Cross Society

Survey Department
Geo-information Unit

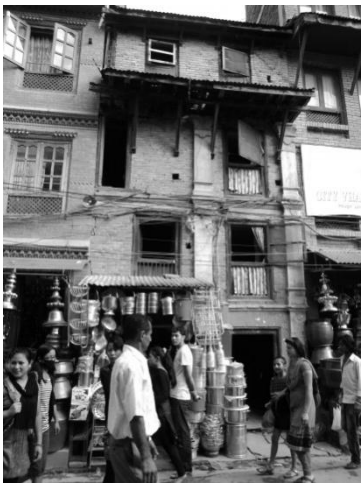
Ward (12) Office

NCDM, DPNet and CORD

LDRMC

Womens' Group

Enumerators given training for Survey



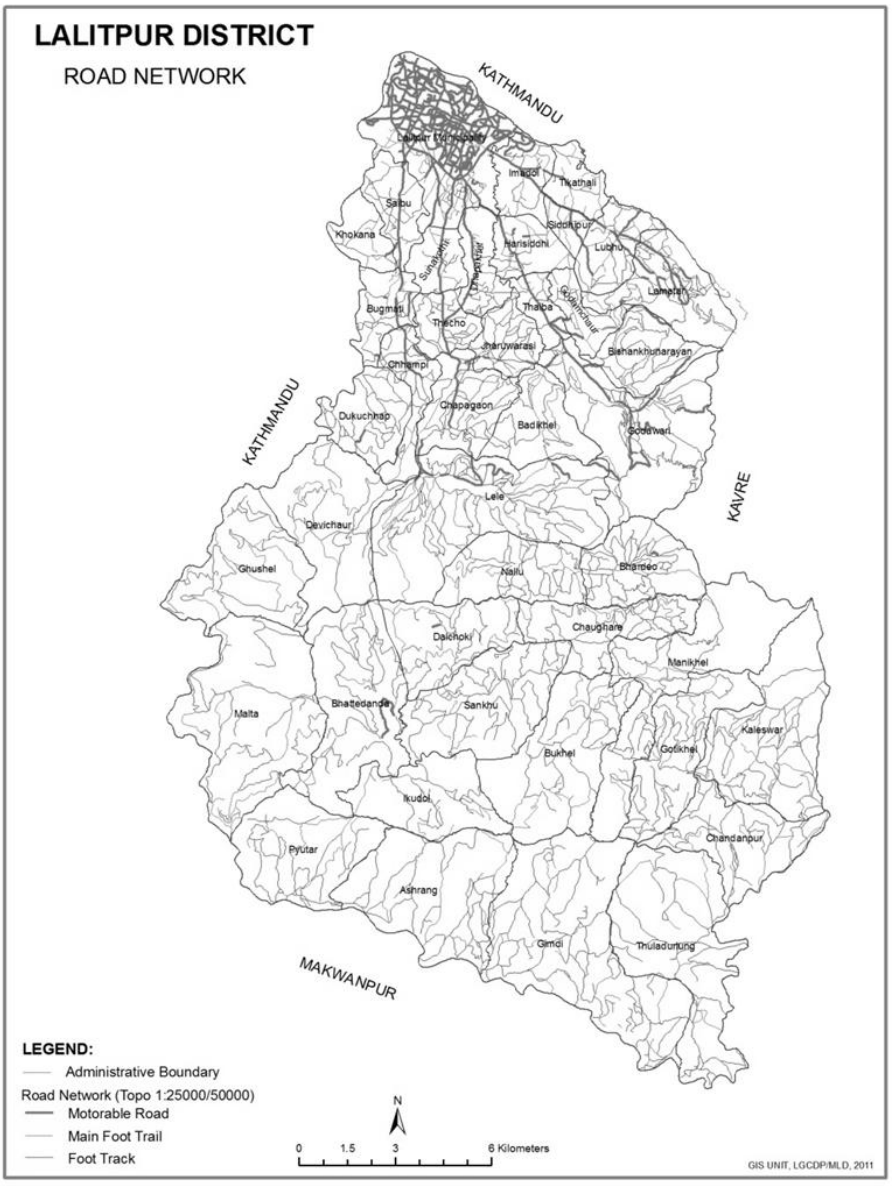
Types of houses in the Study Area

World Heritage Site near Study Area

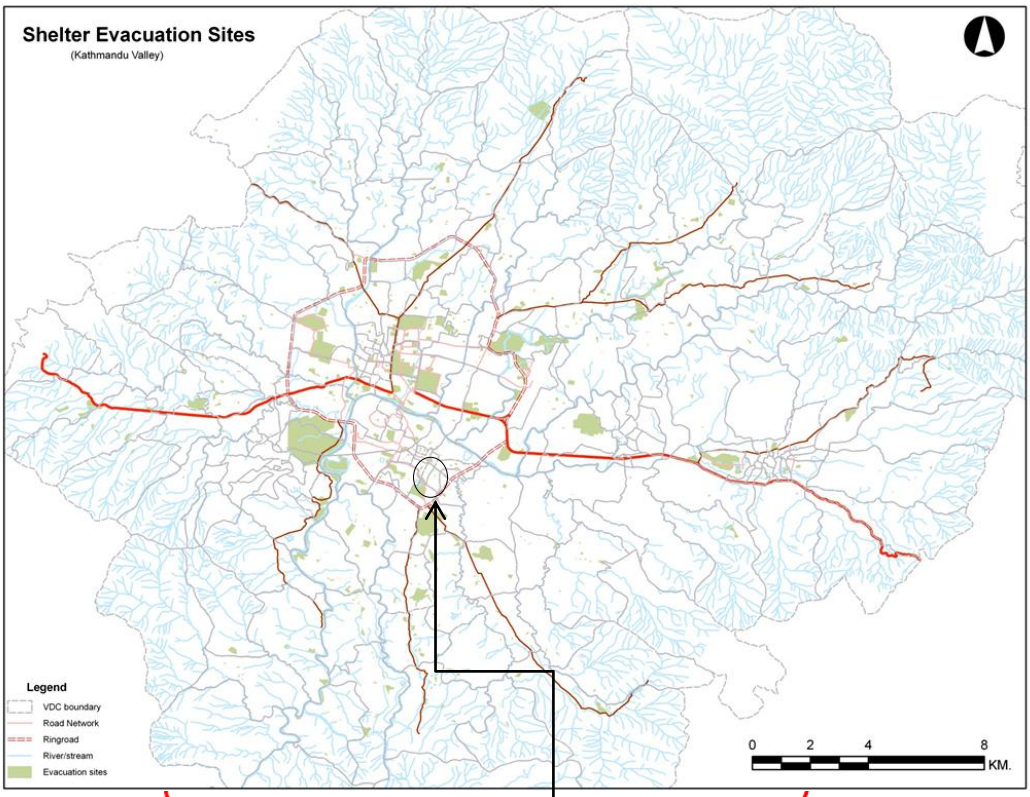
Nepal Red Cross Society giving
Earthquake awareness near Study Area

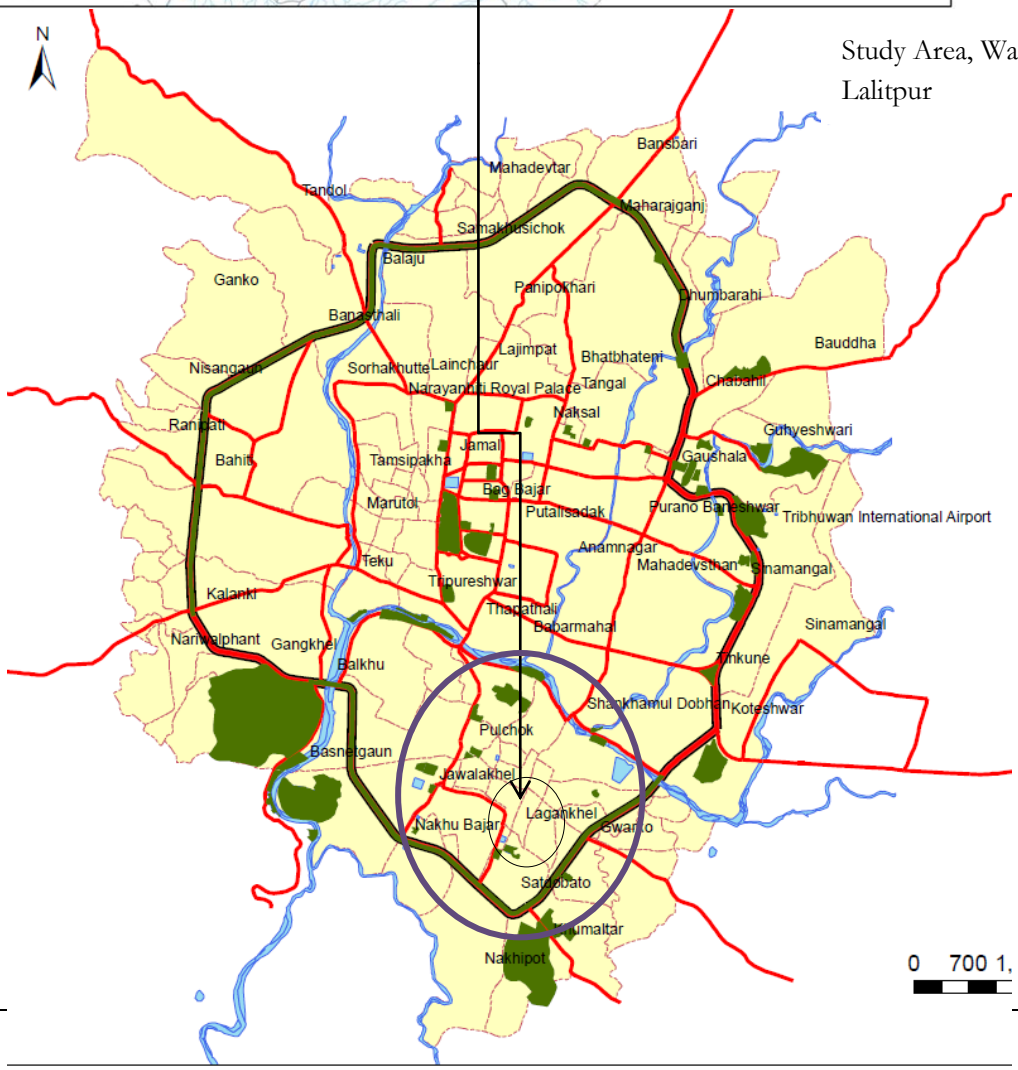
Kathmandu Living Labs
(OpenStreetMaps)

**<u>Appendix 5.</u> GIS Map of 75 Districts (Lalitpur Administrative Boundary, Road Network) (Source: MoFALD)**



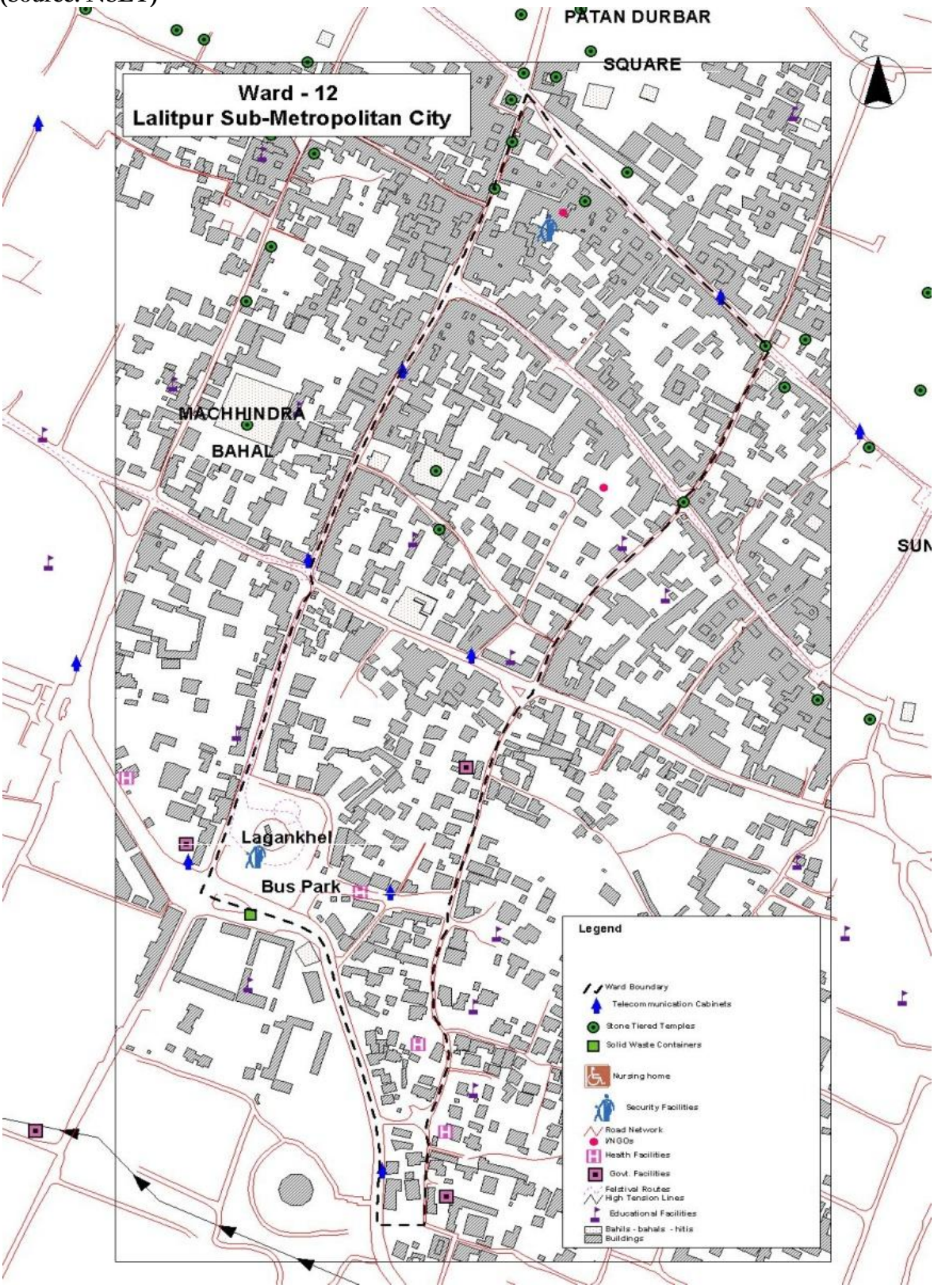
**<u>Appendix 6.</u> Map of Kathmandu Valley with Evacuation Shelters and Study Area indicated (Source: NSET)**



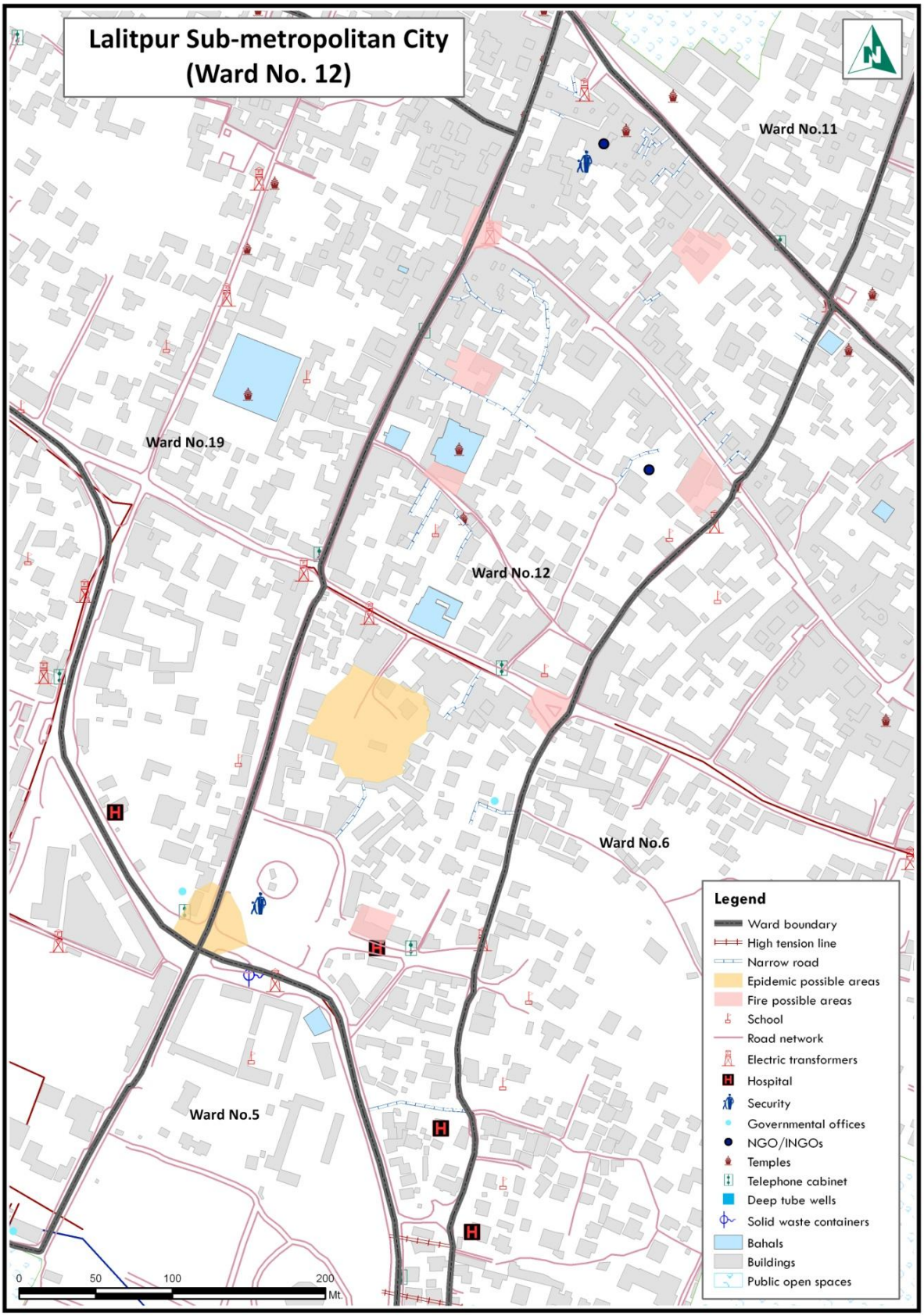




Study Area, Ward no. 12, Patan, Lalitpur

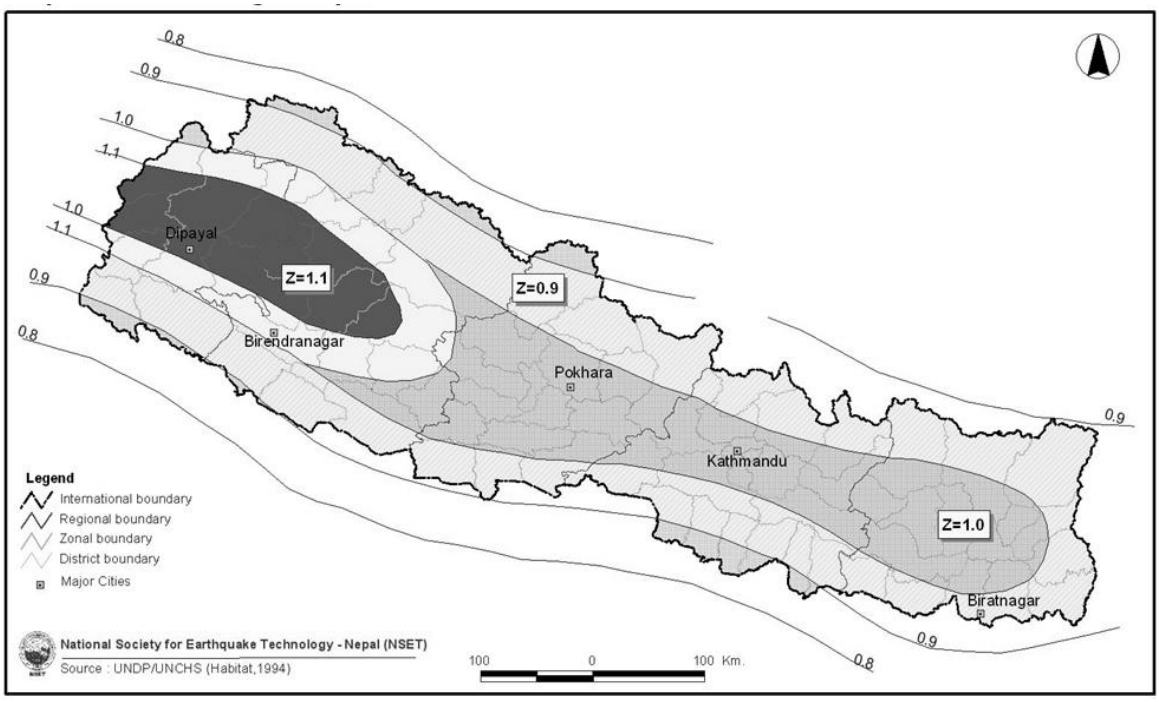
**<u>Appendix 7.</u> Map of Study Area, Ward no. 12, Patan Lalitpur with Security related legend (Source: NSET)**



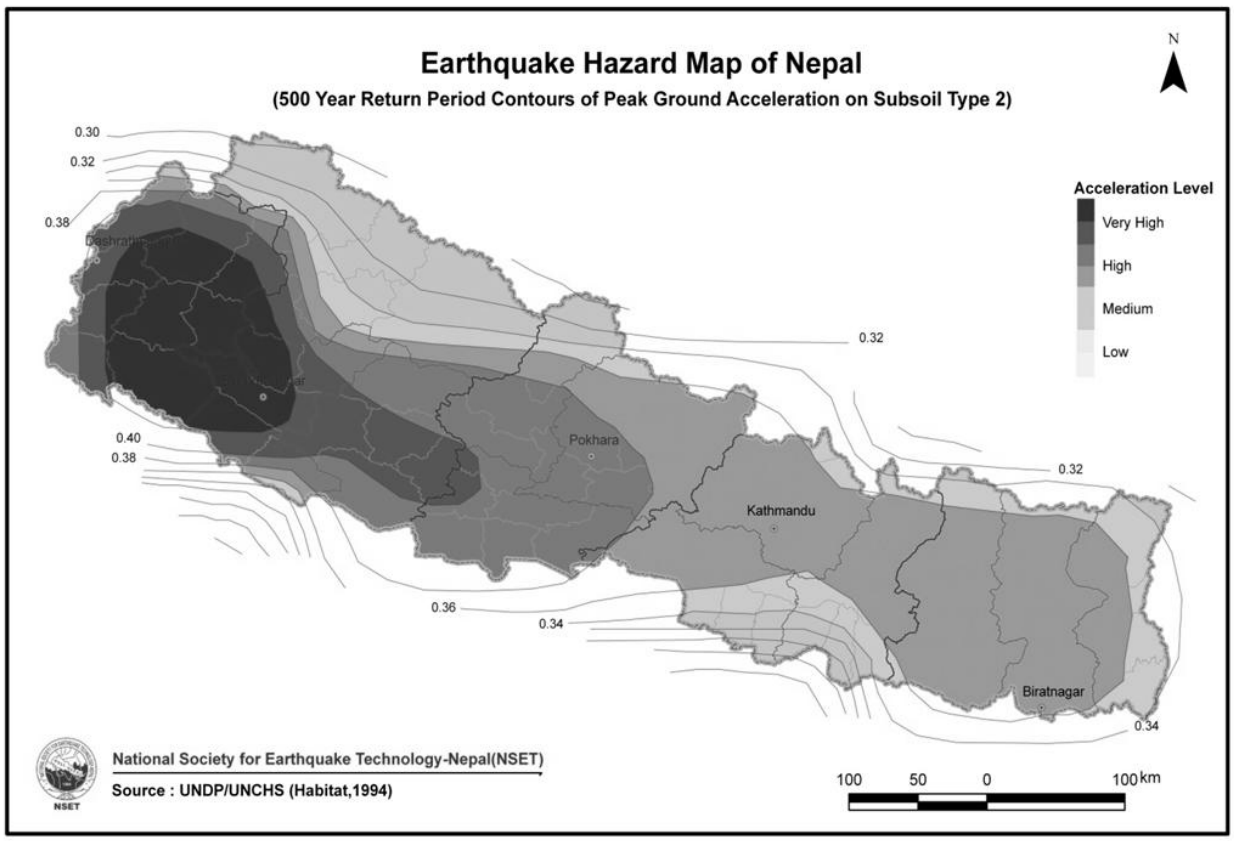
**Appendix 8. Map of Study Area, Ward no. 12, Patan Lalitpur with Disaster related services (Source: NSET)**



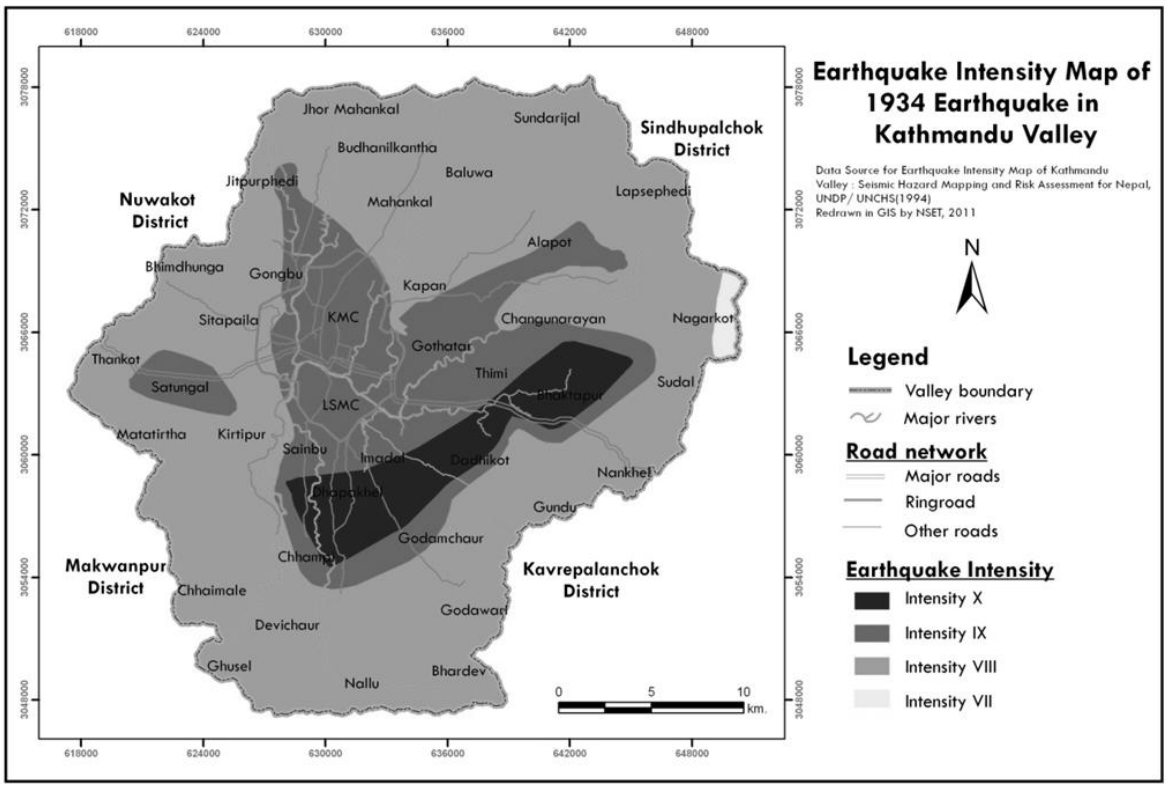
**Appendix 9.** Seismic zoning Map of Nepal (Source: NSET)



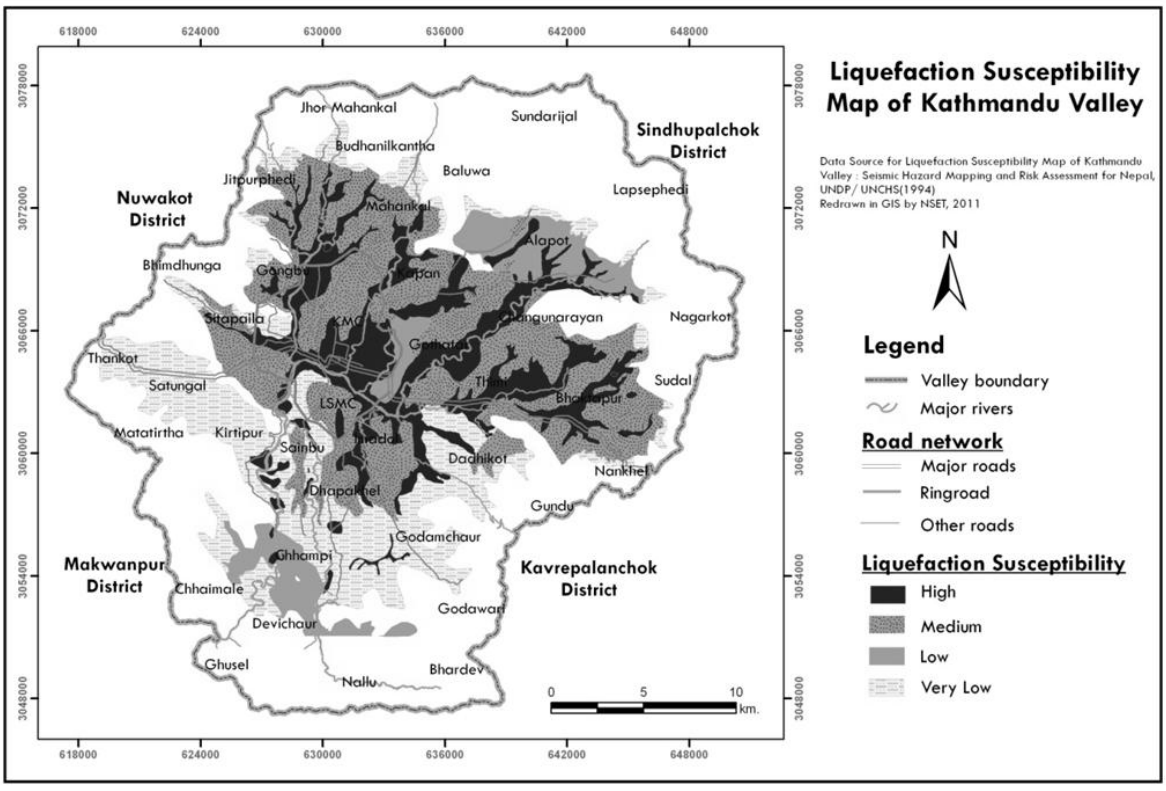

**Appendix 10.** Earthquake Hazard Map of Nepal (Source: NSET)



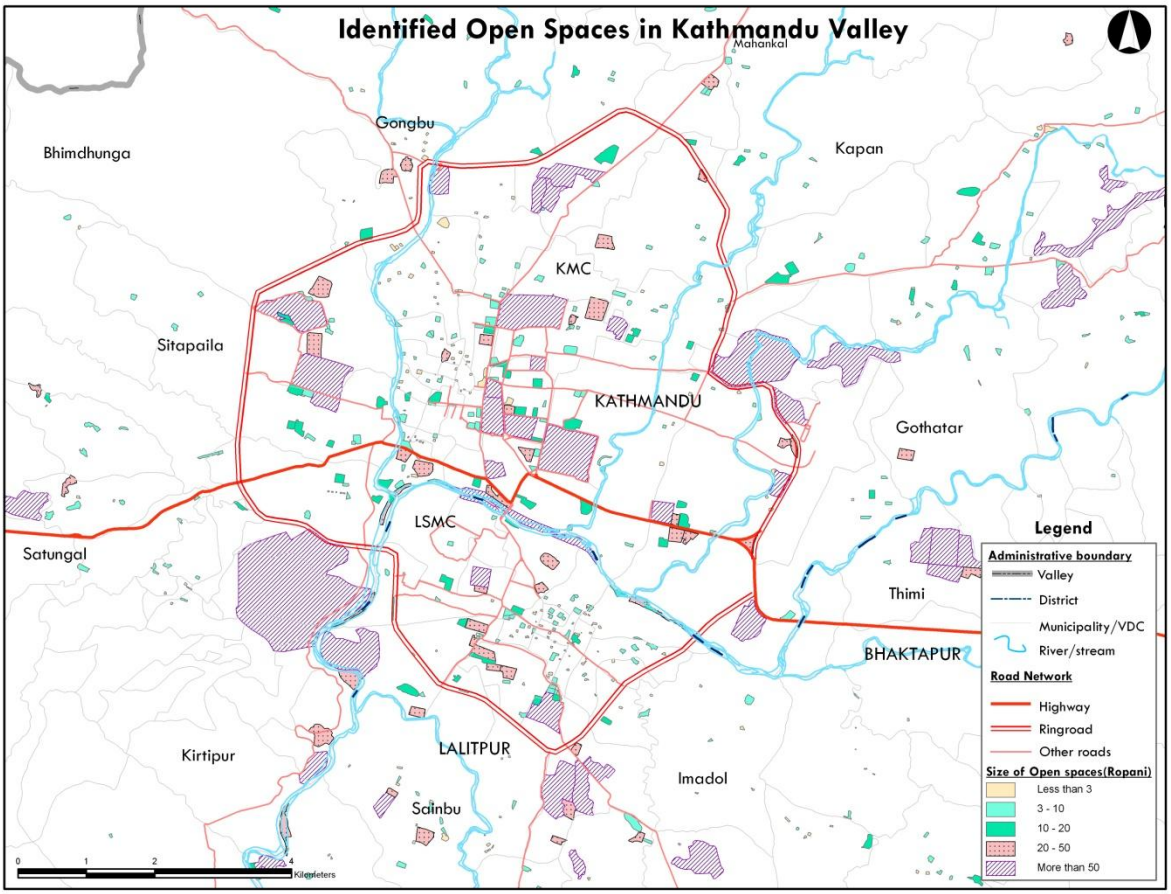
**Appendix 11.** **Earthquake Intensity Map of 1934 Earthquake in Kathmandu Valley (Source: NSET)**



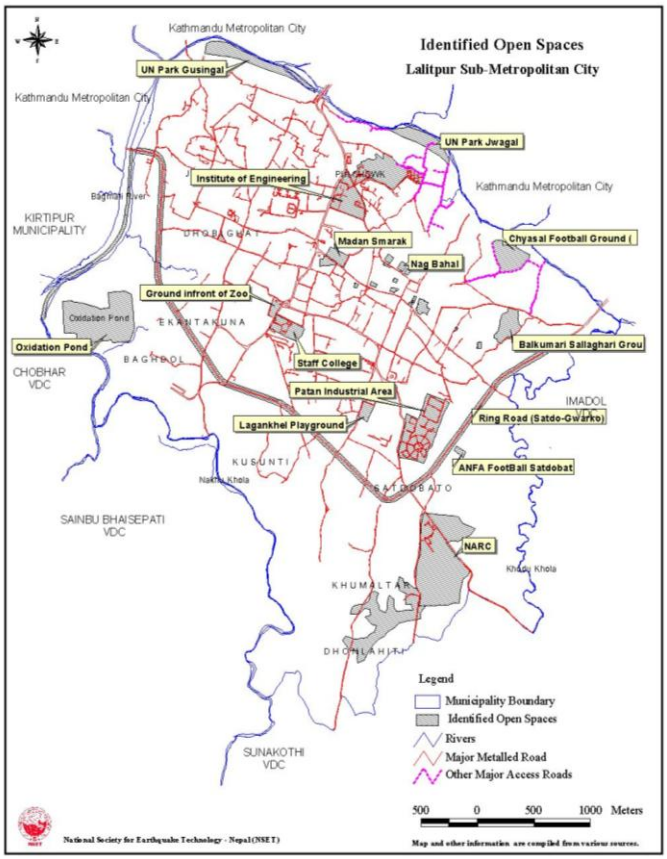

**Appendix 12.** **Earthquake Intensity Map of 1934 Earthquake in Kathmandu Valley (Source: NSET)**



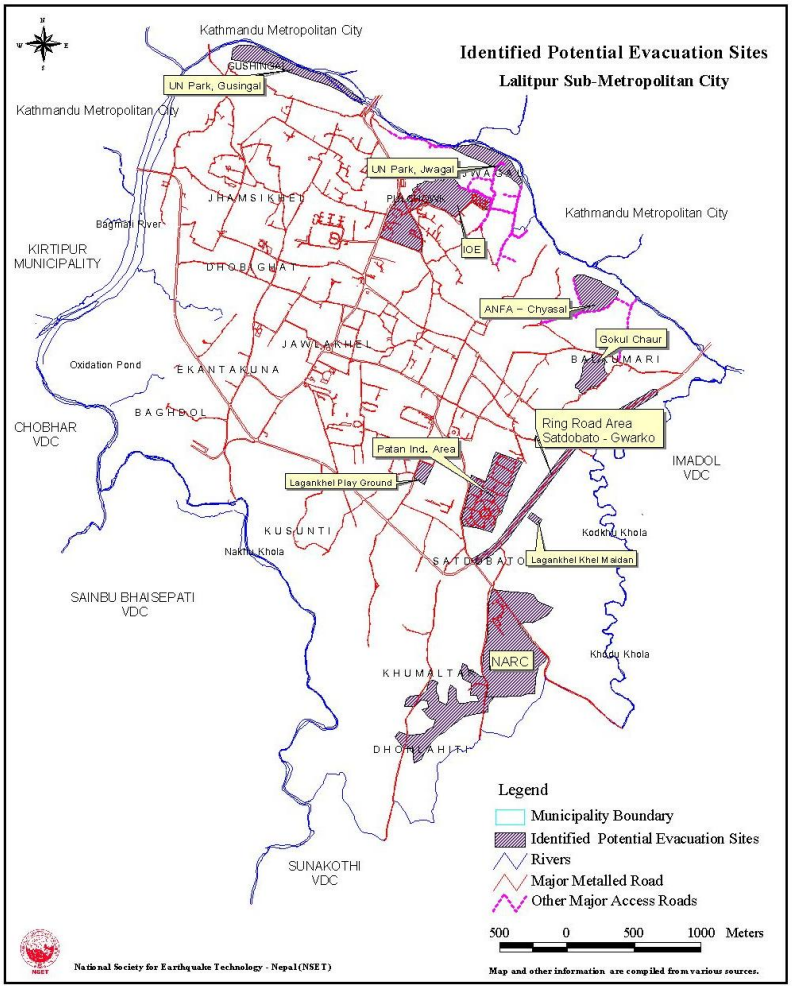
**Appendix 13.** Identified Open Spaces in Kathmandu Valley (Source: NSET)



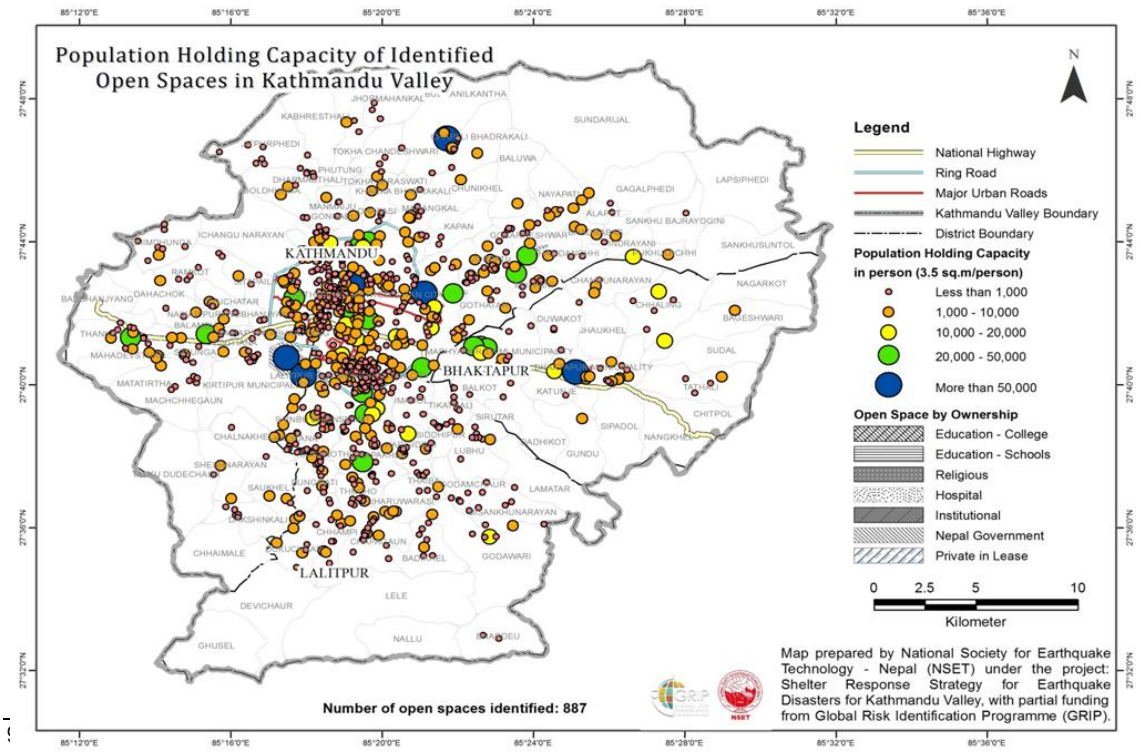

**Appendix 14.** Identified Open Spaces (Lalitpur Sub-Metropolitan City) (Source: NSET)



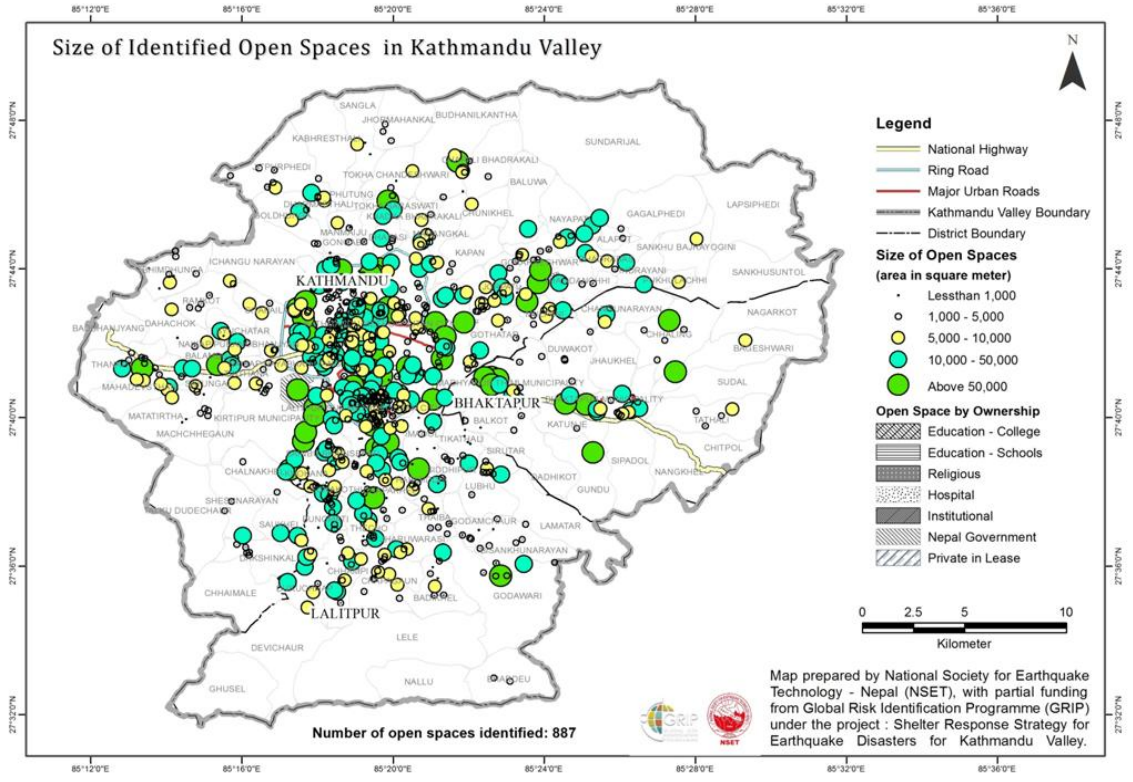
**Appendix 15. Identified Potential Evacuation Sites (Lalitpur Sub-Metropolitan City) (Source: NSET)**



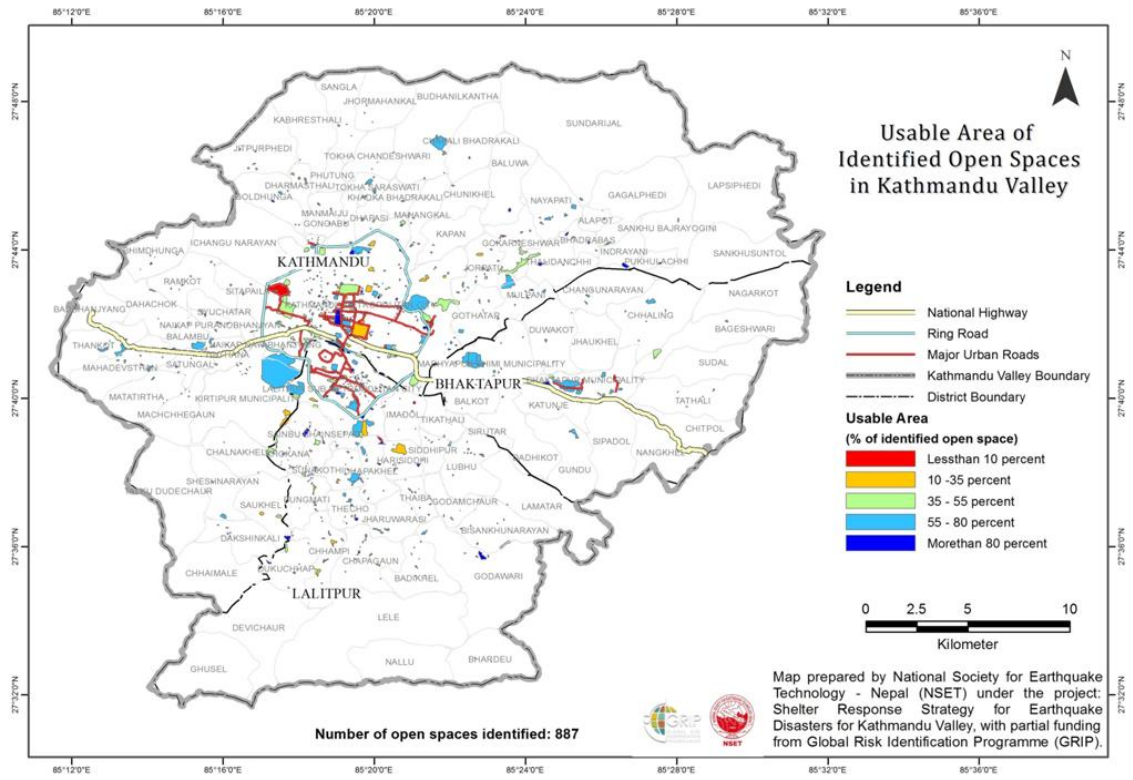

**Appendix 16. Population Holding Capacity of Identified Open Spaces in Kathmandu Valley (Source: NSET)**



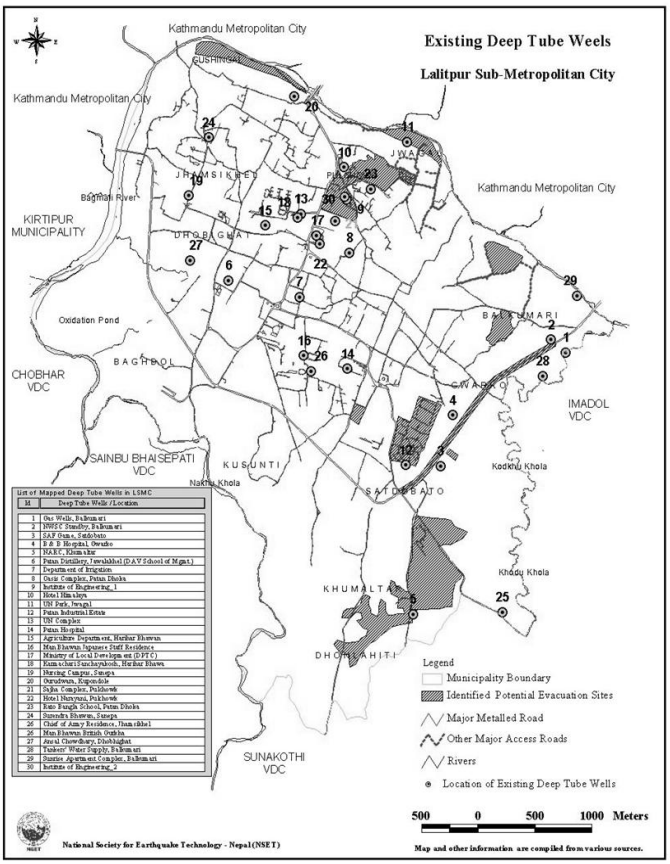
**Appendix 17. Size of Identified Open Spaces in Kathmandu Valley (Source: NSET)**



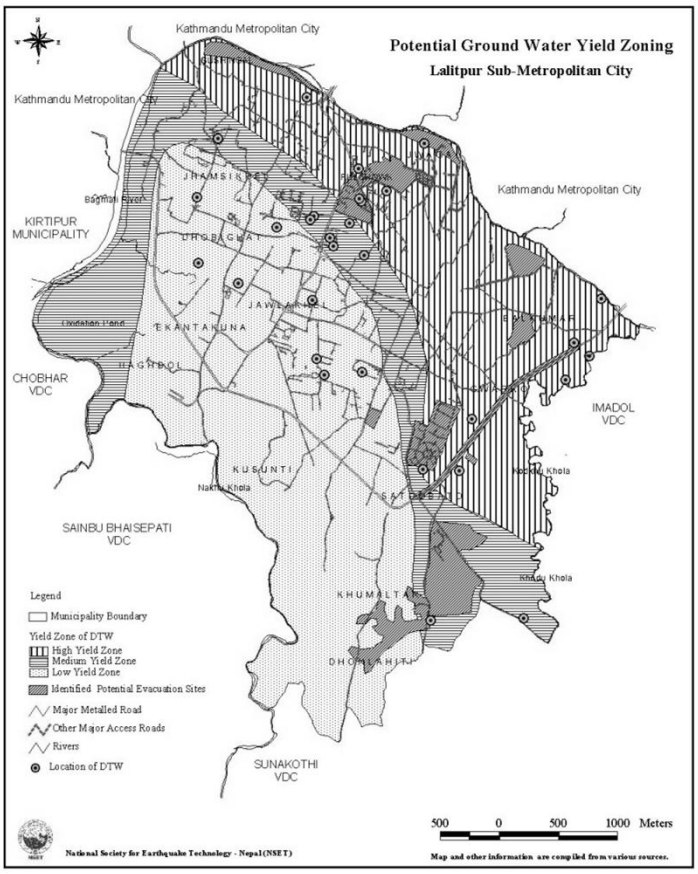

**Appendix 18. Usable area of Identified Open Spaces in Kathmandu Valley (Source: NSET)**



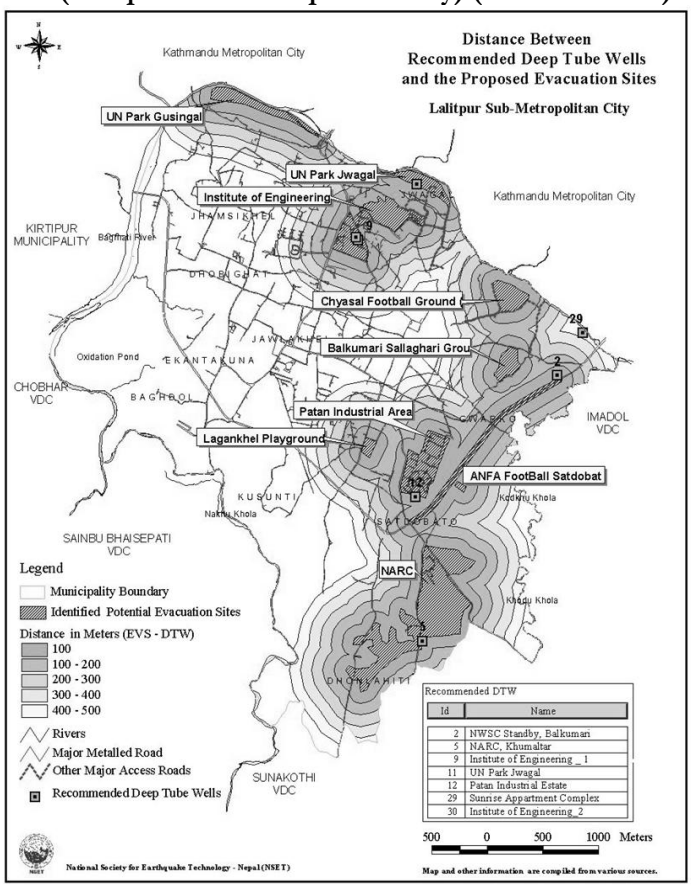
**Appendix 19. Potential Ground Water Yield Zoning (Lalitpur Sub-Metropolitan City) (Source: NSET)**



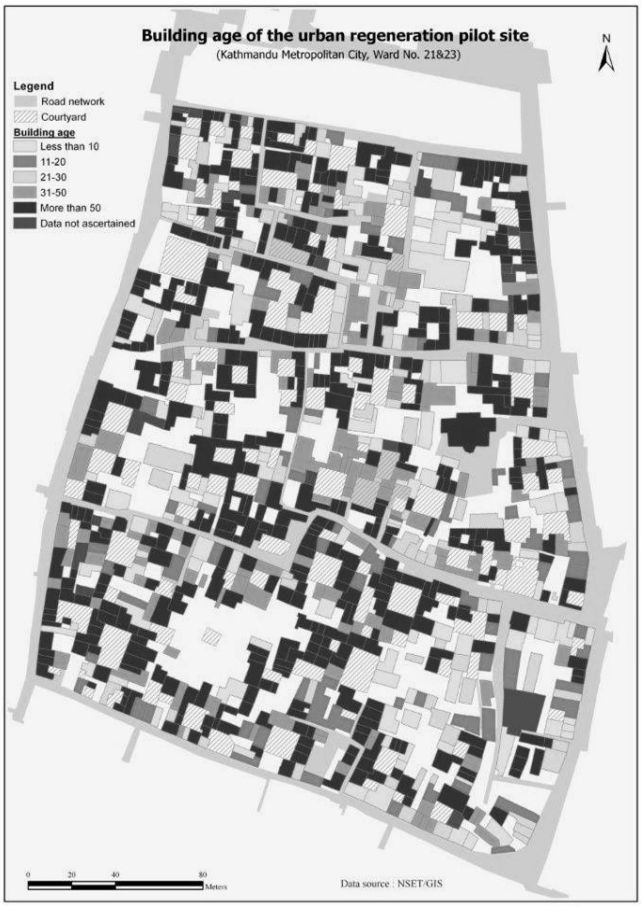

**Appendix 20. Existing Deep Tube Wells (Lalitpur Sub-Metropolitan City) (Source: NSET)**



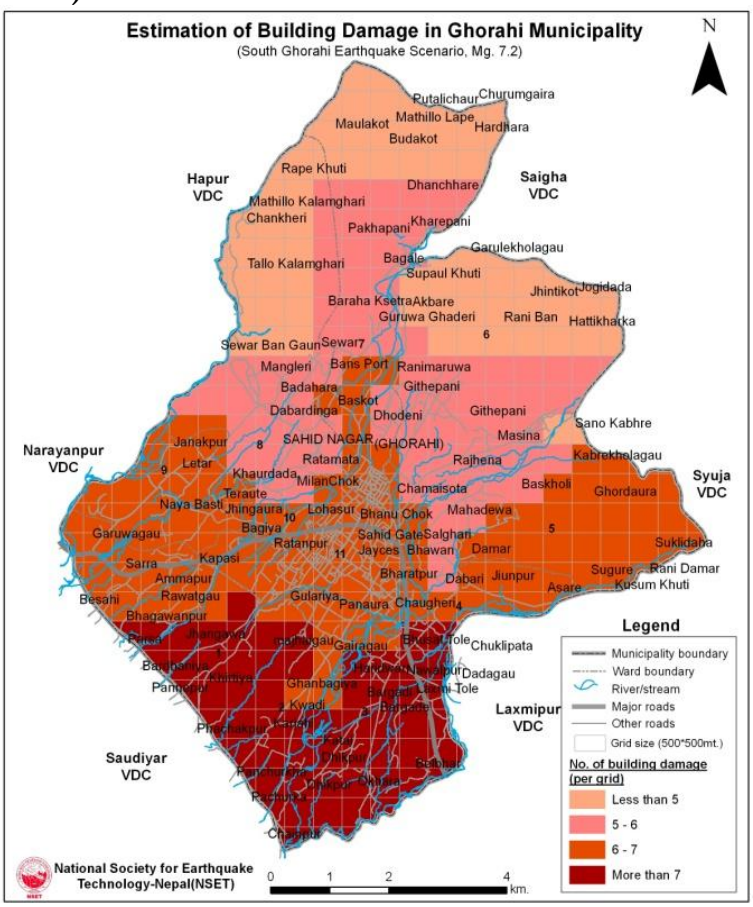
**Appendix 21. Distance between Recommended Deep Tube Wells and the Proposed Evacuation Sites (Lalitpur Sub-Metropolitan City) (Source: NSET)**



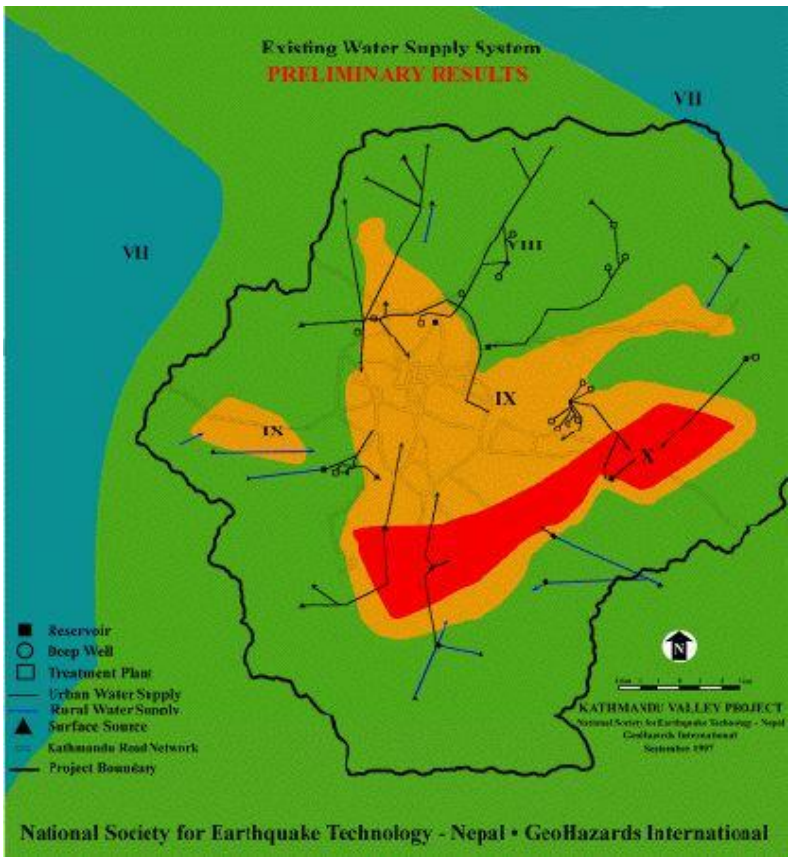

**Appendix 22. Building Age of the Urban Regeneration Pilot Site (Kathmandu Metropolitan City, Ward No. 21 &23) (Source: NSET)**



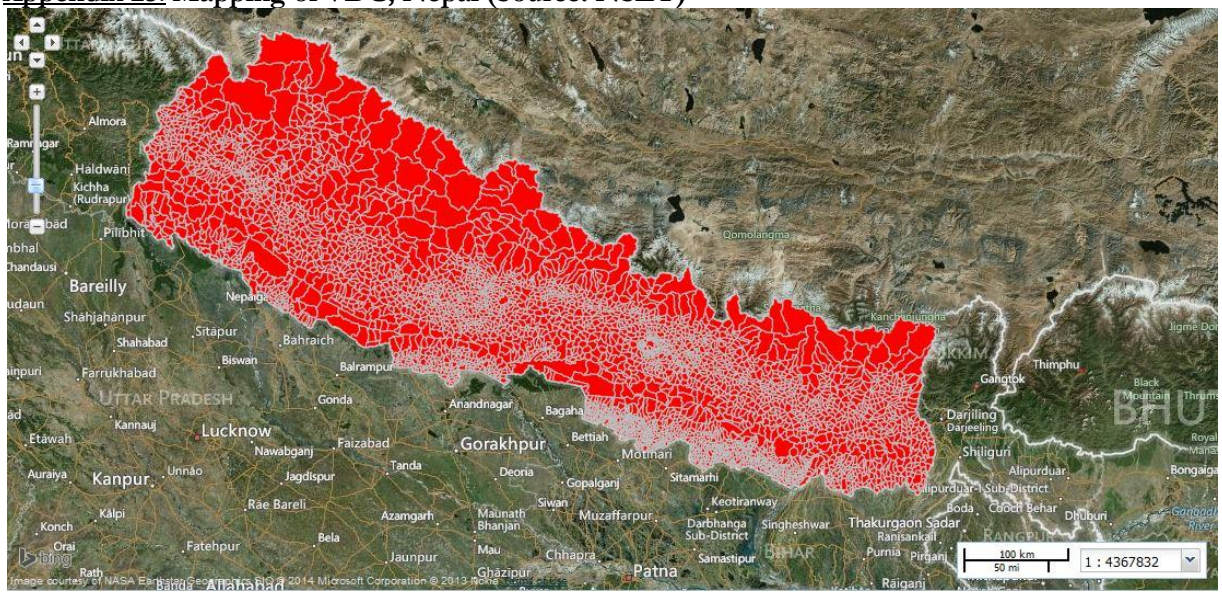
**Appendix 23. Ghorahi Municipality (South Ghorahi Earthquake Scenario, Mg. 7.2.) (Source: NSET)**



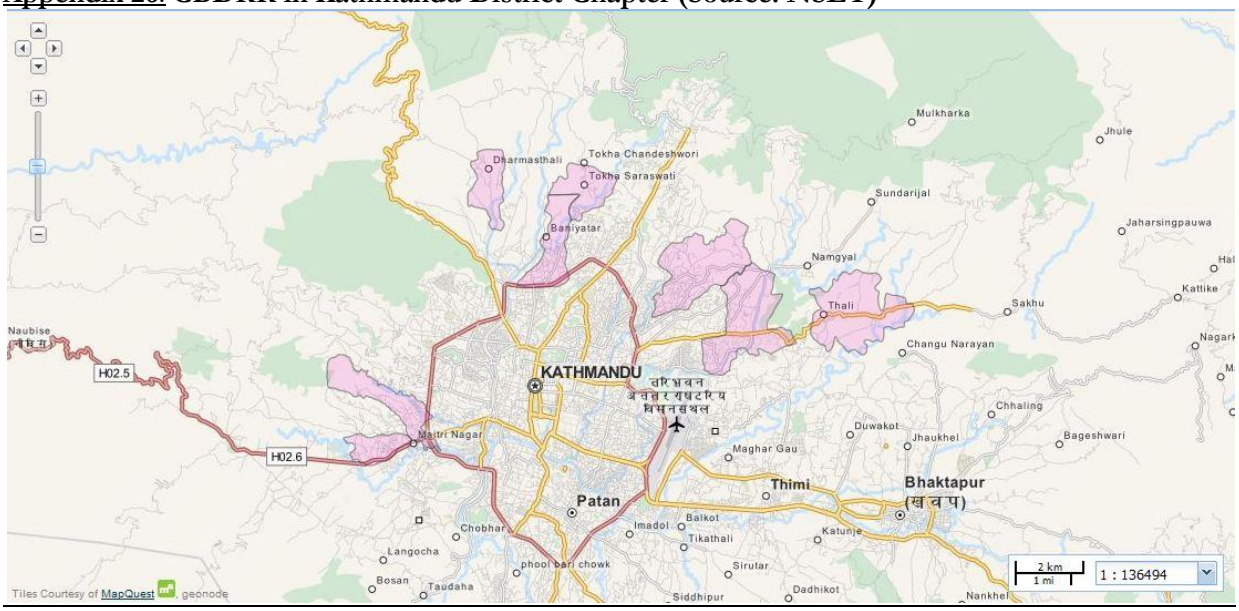

**Appendix 24. Existing Water Supply System (Preliminary Results) Mapping of VDC, Nepal (Source: NSET)**



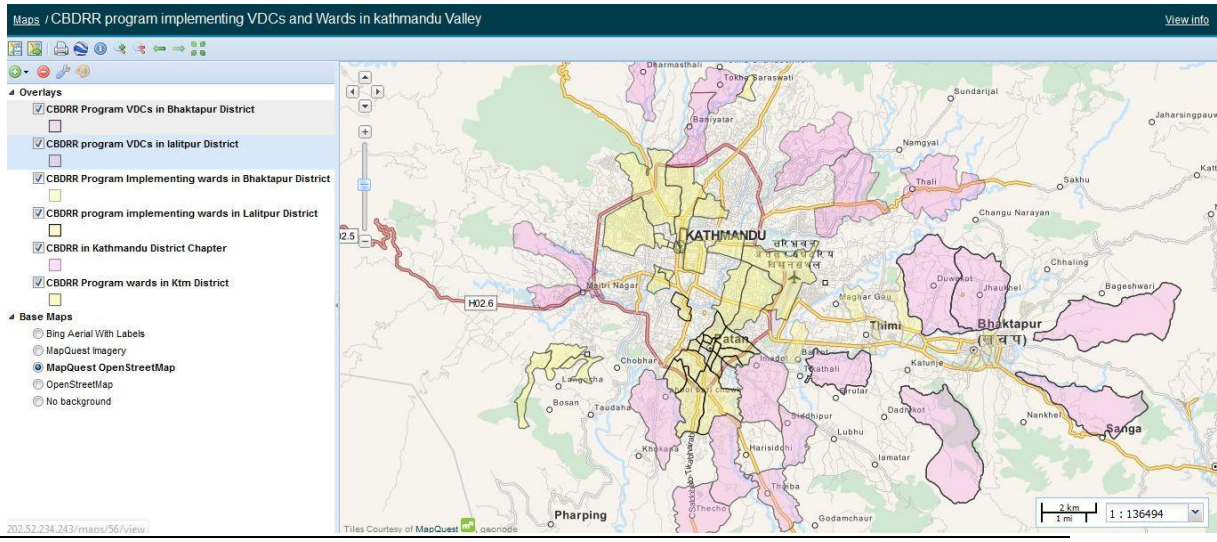
**Appendix 25. Mapping of VDC, Nepal (Source: NSET)**



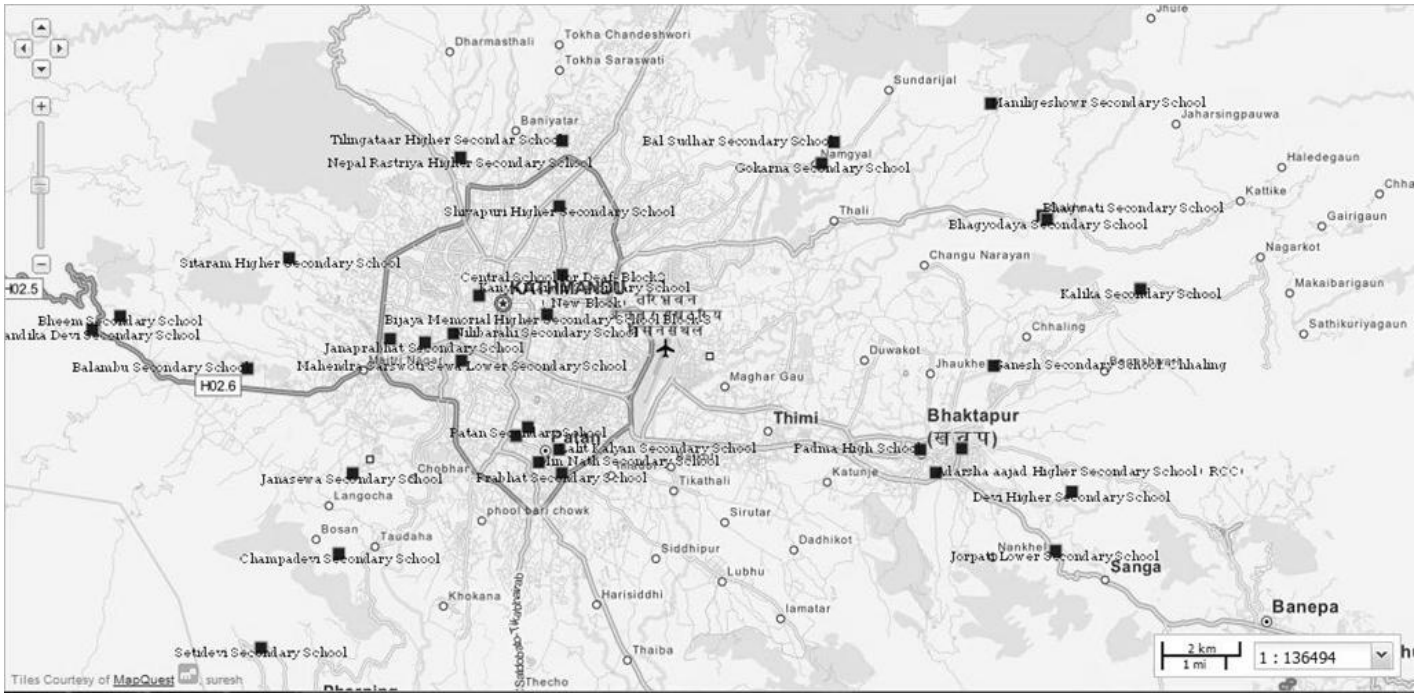

**Appendix 26. CBDRR in Kathmandu District Chapter (Source: NSET)**



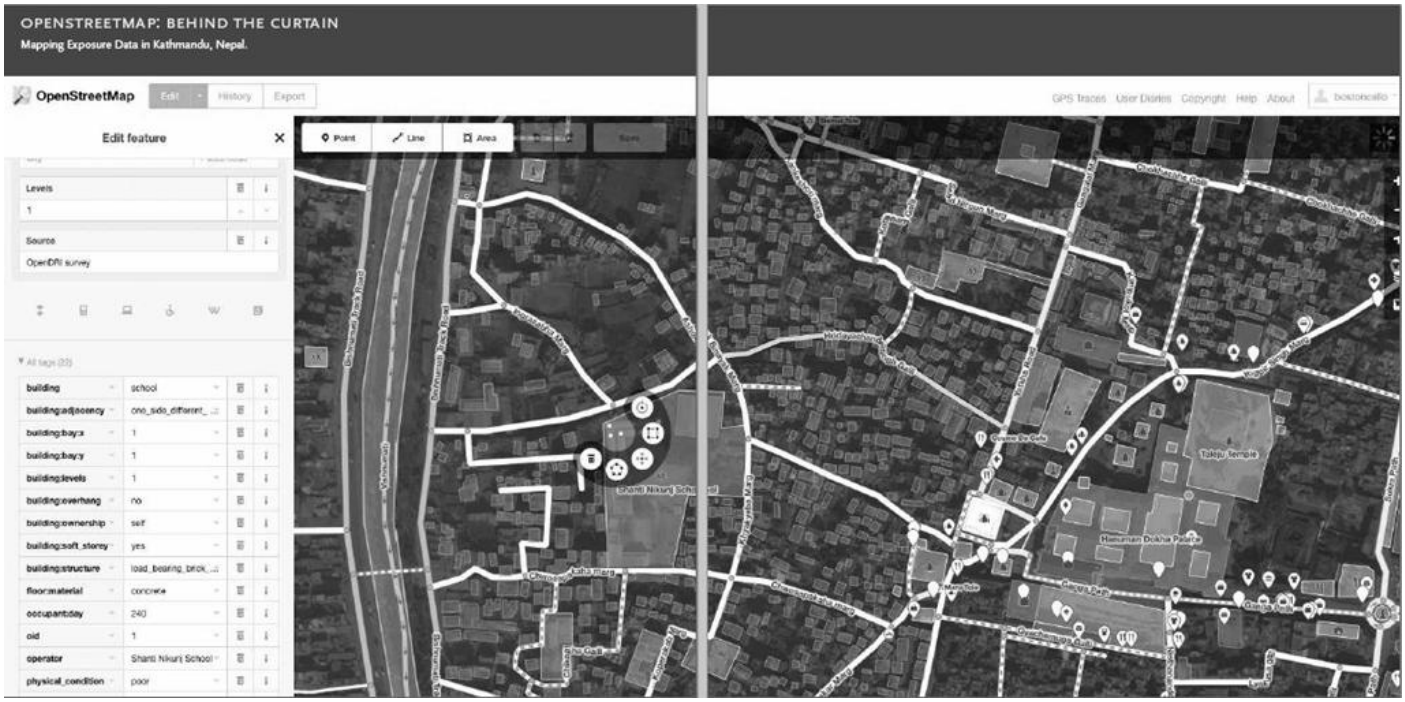

**Appendix 27. CBDRR Program Implementing VDCs and Wards in Kathmandu Valley (Source: NSET)**



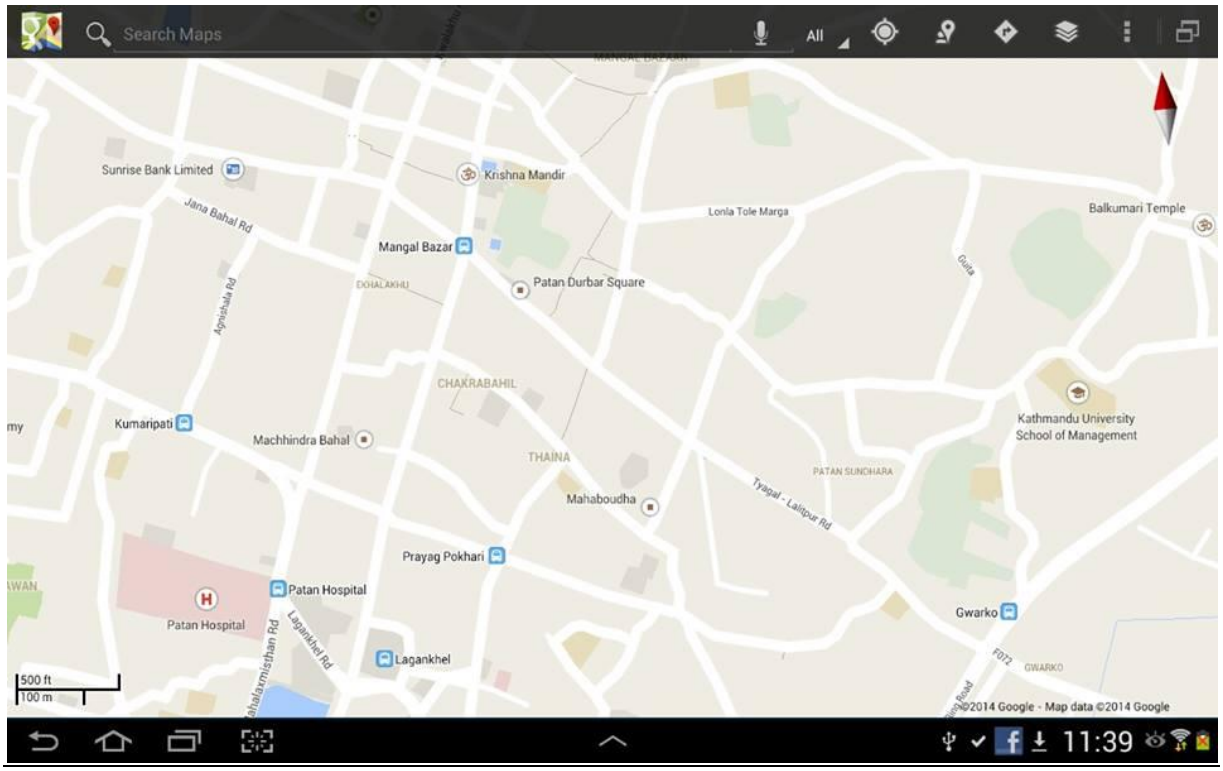
**Appendix 28. School Earthquake Safety Program in Kathmandu Valley (Source: NSET)**



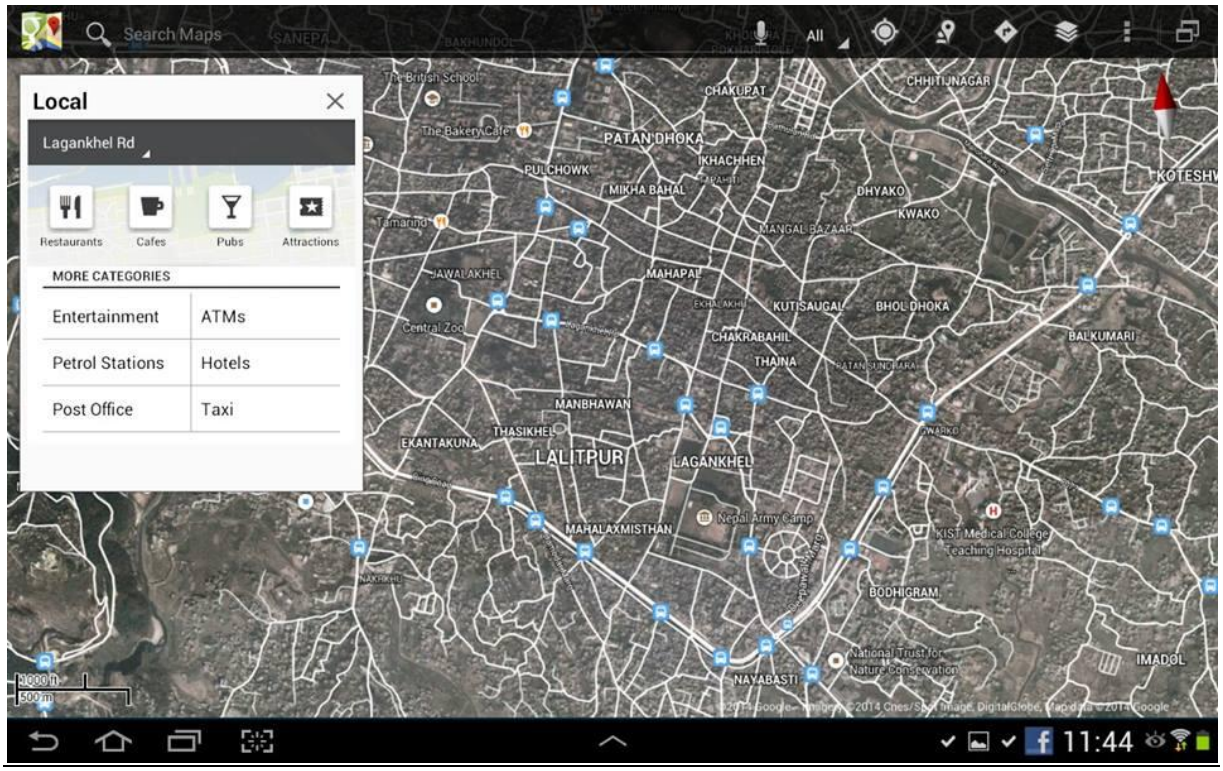

**Appendix 29. OpenStreetMaps (Source: Kathmandu Living Labs)**



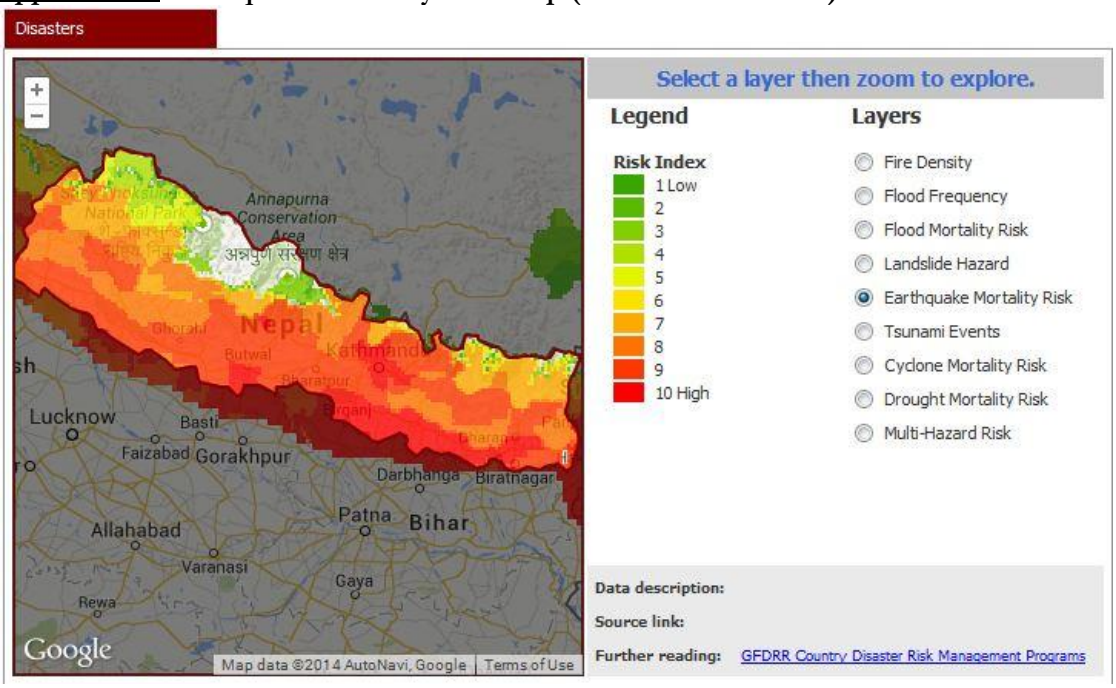
**Appendix 30.** **OpenStreetMaps of Study Area (Source: Kathmandu Living Labs)**



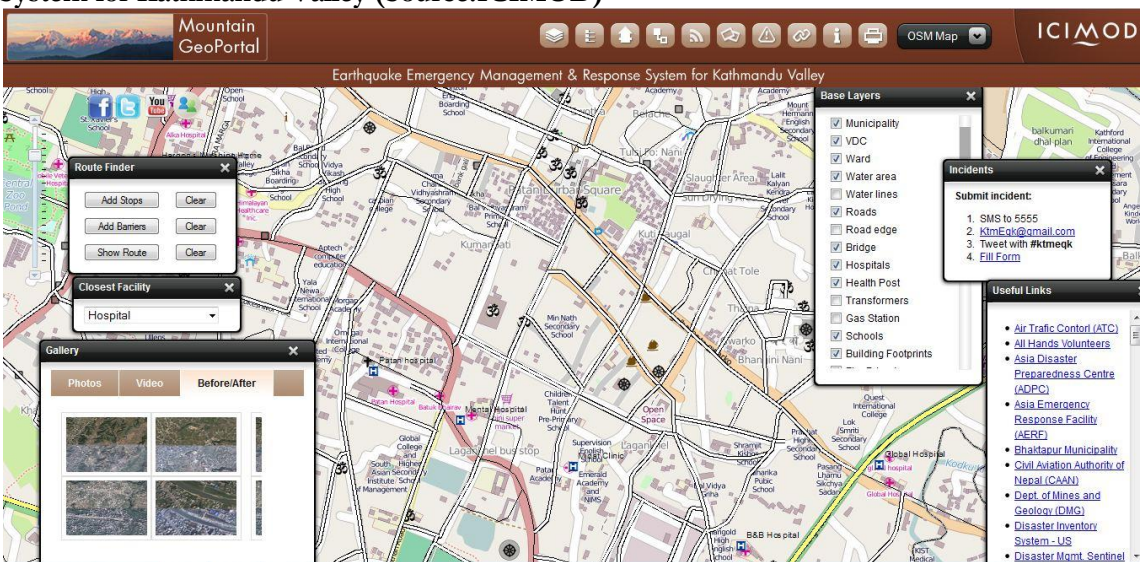

**Appendix 31.** **OpenStreetMaps of Study Area (sattelite layer) (Source: Kathmandu Living Labs)**

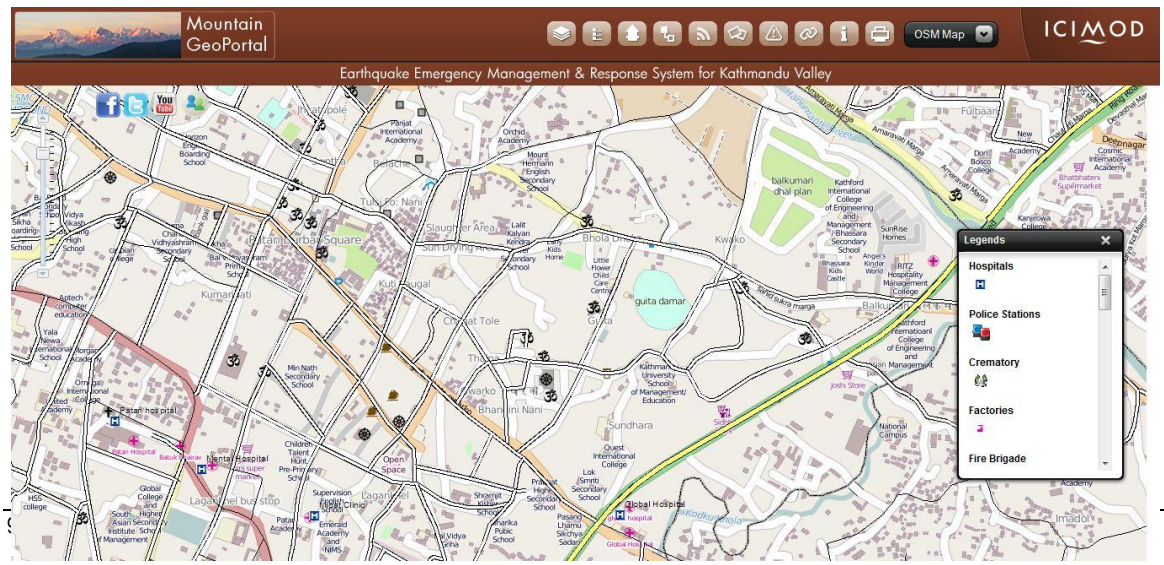


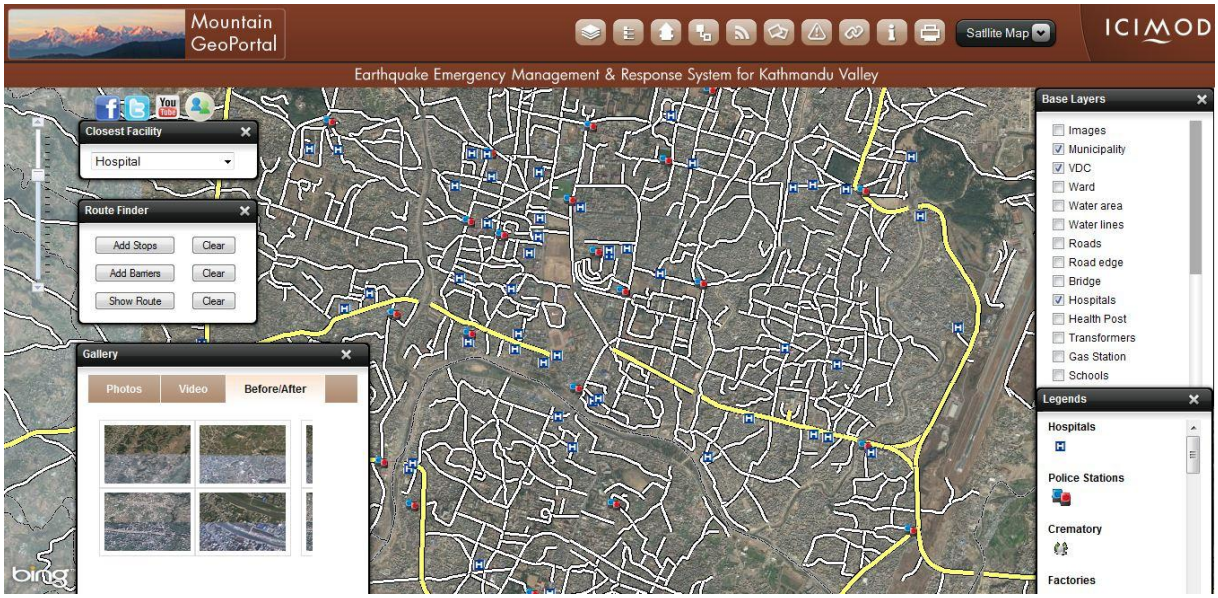
**Appendix 32.** Earthquake Mortality Risk Map (Source: World Bank)




**Appendix 33.** GeoMountain, GeoPortal for Earthquake Emergency Management and Response System for Kathmandu Valley (Source:ICIMOD)






**Appendix 34. Interview Questionnaire (Community/Individuals)**

***Topic: Improving Community Resilience in Earthquake Disaster with increased access to Geo-information***

# Household Survey Questionnaire

## 1. GENERAL INFORMATION

- Have you experienced an earthquake? a. Yes b. No

  If yes, When?.....

  Can you give details in just one sentence? Impact, what you felt (in one sentence)?

  ……..

Interview No: …… Date of interview: ……. Time: ……...
Interviewee/ Respondent Name: ……
Address: ……tole, Ward no: ……..…, House no: ……...
Age: ……, Gender: ……, Religion: ……, Ethnicity/ Caste:…….
District…… Municipality…….....
Coordinates (if any) GPS reading: X: …… Y: ……

Were you in a building? a. Yes b. No (If no, where were you)? …….

- Do you know what causes an earthquake to occur? a. God b. Natural Disaster

  If you choose (a), do you think that earthquakes are the results of sin committed by human beings?
  a. Yes b. No c. No idea
- In your opinion, who kills: the earthquake or the building?

a. The earthquake b. The building

## 2. SOCIAL RESILIENCE

- **Educational level (details of the household) and Age level**

  No of family members: ……....
  No of members in the house: ……..

| S.No. | Relation of respondent | Age | Gender | Education Illiterate/ Primary School/ Sec. | Physically Disabled | Mentally Disabled | Pregnant Women |
|---|---|---|---|---|---|---|---|

| | including him/herself | | | School Intermediate/University | (Tick if yes) | (Tick if yes) | (Tick if yes) |
|---|---|---|---|---|---|---|---|
| 1. | | | | | | | |
| 2. | | | | | | | |
| 3. | | | | | | | |
| 4. | | | | | | | |
| 5. | | | | | | | |
| 6. | | | | | | | |
| 7. | | | | | | | |
| 8. | | | | | | | |
| 9. | | | | | | | |
| 10. | | | | | | | |

- **Membership of social institution (Involvement of family members in community activities):**

| S.No. | Community group | Tick the appropriate one |
|---|---|---|
| | Local Disaster Risk Management Committee (LDRMC) | |
| 1. | ToleSudharSamiti | |
| 2. | Traditional Guthi | |
| 3. | Women's group | |
| 4. | Youth club | |
| 3. | Other (please specify) | |

**3. <u>ECONOMIC RESILIENCE</u>**

- **Housing Capital:**

  Do you own this house?

  **a.** Own house b. Rented house c. Other

- **Employment**

  Are you employed?

  a. Yes b. No

- **Single and multiple sources income**

  Do you have multiple sources of income?

  a. Yes b. No

  If yes, name them…….

- **Income level (General monthly household income)**

| S.No. | Amount | Tick the appropriate one |
|---|---|---|
| 1. | NRs. 8000 or less | |
| 2. | NRs. 8000 to NRs. 16000 | |
| 3. | NRs. 16000 to NRs. 25000 | |
| 4. | NRs. 25000 to NRs. 40000 | |
| 5. | NRs. 40000 or more | |

Nepal Living Standard Survey 2011

**4. <u>INSTITUTIONAL RESILIENCE</u>**

- **Mitigation**

  Have you exercised any Disaster Risk Management Plan?

  a. Yes b. No

- **Awareness building**

  Have you participated in any earthquake related training?

  a. Yes b. No

  If yes, who gave you this training?.....

**5. <u>PHYSICAL (SHELTER) RESILIENCE</u>**

- **Shelter capacity**

  Do you have vacant rooms for rent?

  a. Yes b. No

- **House age**

  What is the age of your house?

  …….

Have you followed the building rules/ codes while building the house?

a. Yes b. No c. No idea

- **Location**

Do you have another house?

If yes, where?

a. City core b. Perifery

**i. ADDITIONAL QUESTIONS OF GENERAL INFORMATION**

- Are earthquakes a concern for you and your household?

  a. Yes b. No

  If yes, do you discuss and build awareness within family regarding earthquake disaster?

  a. Yes b. No

  If no, why? ……

- Are you doing anything to prepare for an earthquake?

  a. Yes b. No

If yes, please give details (in one sentence)?.....

If no, why not (in one sentence)?.....

- Have you followed programs on earthquake disasters over radio/TV? a. Yes b. No

  If yes when? a. After the earthquake b. Every other day

- Do such programs share knowledge on increasing earthquake resilience?

  a. To a great extent b. Somewhat c. Very little d. Not at all

- Have you ever received information that could help you **prepare** for an earthquake?

  a. Yes b. No

  If yes, what was source of information (school children, media, theatre, others)?

  ……

- Have you ever received information that could help you **react/respond** to an earthquake?

  a. Yes b. No

  If yes, what was source of information (school children, media, theatre, others)?

  …….

- Have you identified safer place in your house regarding earthquake disaster?

  a. Yes b. No

  If yes, where?

  a. Under the table b. Under the bed c. In Chhidi (ground floor) d. Others……

- Do you have first aid kits in the household?

  a. Yes b. No

- Do you have earthquake kits/ storage?

  a. Yes b. No

  If yes, what?

  …….

**ii. ADDITIONAL QUESTIONS OF SOCIAL RESILIENCE**

- Are you introduced with your neighbors?

  a. Yes b. No

  If yes, how

  a. I know all of them b. I know most of them c. I know few of them

- Is your community helpful during hard times in neighborhood?

  a. Always b. Very Often c. Sometimes d. Rarely e. Never

- Who helps you if you have some problems? *Tick the main one*

| | |
|---|---|
| Relatives | District government DDC |
| Friends | National government |
| Neighbors | Local NGO |
| Groups from community | International projects (INGO) |

Insurance company Community organization
Financial institution Women cooperative

- Do you need Community based Disaster Management Organization?
  a. Yes b. No
  If no why……..
- Have you participated in earthquake preparedness programs?
  Yes b. No
- If no, Would you be interested to participate in such organizations if they are established in your community?
  a. Yes b. No
- Are you **involved** in community projects (Earthquake Disaster Risk Management)?
  a. Yes b. No
- Have you been **nominated** to any committee or sub-committee such as Local Disaster Risk Management Committee (LDRMC)?
  a. Yes b. No

  If yes, Have you been **taking part** in the committee meeting?
  a. Yes b. No

  If yes, do you feel **responsible** to volunteer during earthquake disaster? a. Yes b. No

  If yes, do you feel **capable** to volunteer during earthquake disaster? a. Yes b. No
- During the disaster event, do you anticipate receiving orders from the authorities to evacuate?
  a. Yes b. No If yes, whom would you expect from?

  a. Government b. Municipality c. NGO/INGO d. LDRMC (Local Disaster Risk Management Committee) e. *Guthi* f. Others…….
  If yes, where would you go (evacuate)?
  ……
- Do you know the evacuation routes for use after earthquake?
  a. Yes b. No
- Do you know the open spaces for use after earthquake? a. Yes b. No
- Which do you think is the temporary shelter for you in case of earthquake?
  a. Open public space b. Kitchen garden c. Nearby school d. Other……

**iii. <u>ADDITIONAL QUESTIONS OF INSTITUTIONAL RESILIENCE</u>**

- From where do you get news and information of earthquake disaster?
  a. Media b. Ministry c. NGO/INGO d. Municipality e. Ward level f. CBOs (Community based Organizations) g. LDRMC (Local Disaster Risk Management Committee) h. *Guthi* i. Others…….....
- How often do you get news and information about earthquake?
  a. Daily b. weekly c. monthly d. annually
- What type of information is most important to you?

  a. Earthquake disasters information b. House related information c. Health related information d. Information related to security e. Others: …….
- Do you get the information for the **preparation** of earthquake?
  a. Yes b. No
  If yes, from whom?
  a. Media b. Ministry c. NGO/INGO d. Municipality e. Ward level f. CBOs (Community based Organizations) g. LDRMC (Local Disaster Risk Management Committee) h. *Guthi*
  i. Others…….....
- Do you disseminate this information of **preparedness**?
  a. Yes b. No
  If yes, to whom?

a. Media b. Ministry c. NGO/INGO d. Municipality e. Ward level f. CBOs (Community based Organizations) g. LDRMC (Local Disaster Risk Management Committee) h. *Guthi*
i. Others…….....

- Have you participated in the **conduction** of the awareness program a. Yes b. No
  If yes, tick the awareness programs that you have participated to conduct:
  - Identifying safe areas in building
  - Duck, cover and hold
  - Information of earthquake kit
  - Identification of evacuation routes
  - Identification of shelter area

- Do you get the information of the need of **coping**?
  a. Yes b. No
  If yes, from whom?
  a. Media b. Ministry c. NGO/INGO d. Municipality e. Ward level f. CBOs (Community based Organizations) g. LDRMC (Local Disaster Risk Management Committee)
  h. *Guthi* i. Others…….....
- Do you flow/ disseminate this information of **coping**?
  a. Yes b. No
  If yes, to whom?
  a. Media b. Ministry c. NGO/INGO d. Municipality e. Ward level f. CBOs (Community based
  Organizations) g. LDRMC (Local Disaster Risk Management Committee) h. *Guthi*
  i. Others…….....
- Have you participated the **training** for awareness? a. Yes b. No
  If yes, tick the trainings for awareness that you participated such as:
  - Identifying safe areas in building
  - Duck, cover and hold
  - Information of earthquake kit
  - Identification of evacuation routes
  - Identification of shelter area
- Do you get the information on **recovery**?
  a. Yes b. No
  If yes, from whom?
  a. Media b. Ministry c. NGO/INGO d. Municipality e. Ward level f. CBOs (Community based Organizations) g. LDRMC (Local Disaster Risk Management Committee) h. *Guthi*
  i. Others…….....
- Do you flow/ disseminate this information of **recovery**?
  a. Yes b. No
  If yes, to whom?
  a. Media b. Ministry c. NGO/INGO d. Municipality e. Ward level f. CBOs (Community based Organizations) g. LDRMC (Local Disaster Risk Management Committee)
  h. *Guthi* i. Others…….....
- Have you got trainings/ information on **how to act**? a. Yes b. No
  If yes, tick the trainings/ information on how to act that you got such as:
  - Triage of the buildings after the earthquake
  - Beginning of livelihood activities
  - Debris Clearance
  - Psychological Counseling
- Do you flow/ disseminate this information on **how to act**?
  a. Yes b. No
  If yes, to whom?

a. Media b. Ministry c. NGO/INGO d. Municipality e. Ward level f. CBOs (Community based Organizations) g. LDRMC (Local Disaster Risk Management Committee)
h. *Guthi* i. Others…….....

- Do you expect information from the national/ central government? a. Yes b. No
  If yes, when?
  a. During preparedness b. During response
- Do you expect information from NGO/INGO? a. Yes b. No
  If yes, when?
  a. During preparedness b. During response
- Do you expect information from municipality?
  a. Yes b. No
  If yes, when?
  a. During preparedness b. During response

iv. **ADDITIONAL QUESTIONS OF PHYSICAL RESILIENCE**

- What is the location of the house?
  a. Near wider road b. Near denser road c. Near courtyard
- What is the primaryconstruction material of your house?
  a. Permanent (e.g. concrete, stone, burnt bricks) b. Semi- permanent c. Temporary (mud, un burnt bricks, wood, thatch)
- How is your building in terms of earthquake hazard?
  a. Risky b. Vulnerable c. Safe
- Do you think building bye-laws could help increasing resilience to earthquake?
  a. Yes b. No c. No idea

  If no, why?
  1. Lack of monitoring
  2. Lack of awareness
  3. Lack of context

- Is your house reconstructed?
  a. Yes b. No
  If yes, is it following building bye-laws?
  a. Yes b. No
- Who do you expect to get help to repair/ reconstruct your house after earthquake disaster?

  Government b. Municipality c. NGO/ INGO d. LDRMC (Local Disaster Risk Management Committee) e. *Guthi* f. Relatives g. Self h. Others…….
- Have you retrofitted your building?
  a. Yes b. No

  If yes, Have you prepared engineering drawings to the municipality for the retrofitting of the buildings?
  a. Yes b. No
- Are your neighborhood buildings safe in terms of earthquakes?
  a. Yes b. No c. No idea

- What is the present accessibility the infrastructure in your community?

| Infrastructure | Accessibility (Yes/No) |
|---|---|
| Water supply | |
| Sanitation/ drainage | |
| Telephone | |
| Electricity | |
| Health clinic (distance) | |
| School (distance) | |

- Are annual household surveys done to check your **resilience level**? a. Yes b. No
- Are programs/ street shows done to stay in alert and caution?
  a. Yes b. No

- Who do you think is responsible to **increase** the earthquake resilience? (Tick all applicable)
  a. Government b. Municipality c. NGO/ INGO d. LDRMC (Local Disaster Risk Management Committee) e. *Guthi* f. Relatives f. Technicians g. Community h. Self i. Others…….

## Appendix 35. Interview Questionnaire (Organizations)

The interview was based on questions (unstructured) about the work done in the earthquake, community and resilience related fronts. The information collected from the interviews as well as the secondary data were compared with the framework and the closely related information was used as a part of analysis and discussion in the research. The questionnaires designed for interviews with the key informants from the organization, community, households and individuals were mainly to know what has been done, what they are doing and what are the future work scenario in the field of Disaster Management and specifically Earthquake Management.

- What are the activities carried out by the organization? Elaborate.
- What is done in earthquake and geo-information sector?
- Is community targeted in your endeavours?
- Have you worked for ensuring resilient community?
- What are your suggestions for a earthquake resilient community?

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